Working Time of Danish Seiners during Alaska Pollack Fishery-VIII.*

A collective consideration on the sinking-pulling time

By

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The Alaska Pollack is one of the fishes greatly contributing to the recent increase in the landing by Japanese fleets. And most of the catch, especially their increase in these years, are brought by the factory ship type fishery processing them into either minced fish or fish meal according to the conditions. And how to increase the part of the catch processed into the minced fish is the key point of the effective use of the resources as well as of increasing the economic efficiency of the fleet. It is natural that a good planning for dividing the catch into these two ways of processing should be based on an accurate forecast for the relative abundance of the fishable population in relation to the change of the fishing ability of the boats according to the conditions. And the processing plan can be realized by the smooth supply of the material fish supported by the clear understanding of the behavior pattern and the working speed of the boats under various conditions. The boats start to work from the sunrise and close the work a little after the sunset because of the labor contract in relation to the behavior pattern of the objective fish. They repeat the cycle of works consisting of the following steps during the daytime throughout the season: Laying the net and warp—waiting for the net and warp to sink down—pulling together the warp—hauling up the net to boardside—brailing out the catch. The preceding reports of this series dealt with the change of the times expended on respective steps of works in accordance with the following four factors: The catch[2),4),6)], the depth fished[3),4)], the wave height[5),6)], and the power of main engine of the boats[7)].

A remarkably small variation of the laying time prevented us from examining the influence of these factors on it. But the sinking-pulling time and the hauling-brailing time, consequently the time required for completing a haul, showed large variations; and the relations of these times to each of these factors and to some combinations of them had been examined in the preceding reports[1)-7)]. But there remains a collective consideration on the influence of these factor complex. The present report, accordingly, shows that on the sinking-pulling time. And those on the hauling-brailing time and on the time required for completing a haul will be shown in the succeeding reports.

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Material and Method

The material used in the present series of reports was a complete set of the routine telegrams sent from each of the 22 Danish seiners to the factory ship several times a day throughout the season of 1964. All the telegrams were stratified into the groups of the 10-day intervals according to the calender days. And three days each were randomly chosen from each of the groups of the days. The telegrams on these days were used, after removal of those of the exploratory fishing and the accidental haulings. And from the telegrams of respective hauls, the intervals between the finish of laying the net and warp to the start of hauling the net were timed, and used in the present report (The sinking-pulling time denotes hereafter this interval). All the times were measured in minutes. But those reckoned were aggregated into the groups of the nearest five-minute intervals, because the accuracy of the time measuring was taken into consideration. The boats fished in the zone from 50 m to 150 m deep, chiefly from 90 m to 150 m deep, because they were legally restricted to fish in the grounds not deeper than 150 m. The depth fished was measured in meters with echo-sounder twice a haul, just before laying and hauling the net. The average of them was used here, after aggregation into the groups of the nearest 10 m intervals. Among the 22 Danish seiners supplying the Alaska Pollack to the factory ship studied here, the six boats were equipped with the diesel engine of 270 Hp, the five with 250 Hp, the same number of the boats with 320 Hp, each one of the boats with 220, 230, 275, 290, 310, or 340 Hp. The height of the wind wave was recorded in the grade number according to the standard settled by the Japanese Meteorological Agency.

The preceding reports dealt with the relation of the times expended on respective steps of works to the following four factors: The catch, the depth fished, the wind wave, and the power of main engine of the boats. But the relation to the catch was not dealt with in the present report, because it is less probable that the sinking-pulling time is the dependent variable on the catch but rather probable that the latter depends on the former. The height of wind wave could not be dealt with as one of the independent variables, because this was described in the grade number covering unequal range of wave height[5),6)]. The present report dealt, accordingly, with the change of the sinking-pulling time in accordance with the depth fished and with the power of the boats after stratification of the records according to the grades of wind wave.

Results

In order to find the general relation of the sinking-pulling time to the factor complex, the multiple linear regression equations of it on the depth fished and on the power of main engine were estimated, after the stratification of the records into the seven wind wave grades (Table 1). The regression coefficient on the depth (a_1) was significant in all the wind wave grades except the grades 1 and 7 but that on the power (a_2) was significant only in the grades 2, 3, and 4. This step of examination revealed that the sinking-pulling time

Table 1. The multiple linear regression equations of the sinking-pulling time (t_s in min.) on the depth fished (y in m) and on the power of main engine of the boats (z in horse power) under respective grades of wind wave. $t_s = a_0 + a_1 y + a_2 z$

		a_0	a_1	a_2	F_y	F_z	n_2
Grade of wind wave	1	27.181	−0.059	0.010	0.33	0.45	93
	2	26.518	0.014	−0.018	6.53*	16.43**	1087
	3	21.666	0.040	−0.009	105.85**	5.69*	1288
	4	21.662	0.070	−0.023	51.97**	16.58**	624
	5	21.168	0.036	−0.008	23.16**	2.69	900
	6	19.165	0.049	−0.003	49.48**	0.39	990
	7	30.405	−0.001	−0.010	0.19	0.75	152

Note: df..... $n_1 = 1$ n_2= the value shown in the table
*significant at 0.05 level
**significant at 0.01 level

increased with the depth fished at a rate of from 1.4 min. (the grade 2) to 7 min. (the grade 4) per 100 m increase in the depth fished, but decreased with the power at a rate of from 0.9 min. (the grade 3) to 2.3 min. (the grade 4) per 100 Hp increase in the main engine. The boats fished chiefly in the grounds of from 90 m to 150 m deep, while the main engine varied from 220 Hp to 340 Hp. These facts meant that the difference in the sinking-pulling time due to the depth difference was larger than that due to the power difference.

The multiple linear regression equation does not concern with the probable difference in the influence of one of the independent variables due to the difference in the others. The possibility like this was examined through the comparison of the linear regression coefficients of the sinking-pulling time either on the depth fished or on the power after stratification of the records according to the factor of the rest. The regression coefficient on the power (b_1) was insignificant in the 33 depth-wave groups out of 41 ones (Table 2). And the distribution of the significant coefficients had a relation neither to the grade of wind wave nor to the depth fished. These facts made it hard to give further consideration based on the regression on the power. In contrast with this, the regression coefficient on the depth fished (c_1) was significant in the 20 power-wave groups out of 45 ones (Table 3). And their distribution showed the following trends: They were found chiefly in the wave grades 3 to 6 and for the 230, 250, 270, and 320 Hp groups. These facts suggested a possibility of the difference in c_1 either between the wave grades or between the power groups applicable to the further consideration.

The t-test on the difference in the coefficients (c_1) between the wave grades observable within the same power groups (Table 4) revealed that the significant difference could be found in the 13 combinations of the wave grades out of 90 ones. And their distribution showed a possibility of the boats being classified into the two types in respect of the

Table 2. The linear regression equations of t_s on z, after stratification of the records into the depth zones (10-m intervals) and into the wave grades.

$$t_s = b_0 + b_1 z$$

Grade of wind wave	1				2				3				4			
Depth fished (m)	b_0	b_1	F_b	n_2	b_0	b_1	F_b	n_2	b_0	b_1	F_b	n_2	b_0	b_1	F_b	n_2
50					21.91	0.0001	0.0001	104	25.44	−0.015	2.83	200				
80																
90					35.94	−0.050	4.73*	32					28.02	−0.023	2.53	118
100					30.05	−0.024	11.46**	337	27.75	−0.017	2.98	201	18.88	0.015	0.07	1
110	19.86	0.013	0.59	68	25.43	−0.008	0.51	223	23.70	−0.002	0.02	114	29.88	−0.025	4.52*	111
120	22.69	0.001	0.0005	24	28.30	−0.017	1.58	135	28.37	−0.016	4.07*	260	33.08	−0.038	2.34	37
130					29.16	−0.022	2.40	106	30.65	−0.022	2.00	82	30.21	−0.021	3.94	150
140					30.44	−0.028	4.28*	122	23.79	0.005	0.34	366	30.31	−0.018	2.85	197
150					41.95	−0.059	0.46	12	26.14	−0.006	0.11	51				

Grade of wind wave	5				6				7			
Depth fished (m)	b_0	b_1	F_b	n_2	b_0	b_1	F_b	n_2	b_0	b_1	F_b	n_2
50												
80	22.50	0	0	6	25.68	−0.007	0.01	22				
90	22.62	−0.001	0.02	287	22.61	0.002	0.04	190	36.55	−0.055	9.00	2
100	28.17	−0.019	3.91*	207	20.61	0.008	0.97	297	24.39	−0.003	0.04	130
110	25.00	0	0	1	38.82	−0.054	3.10	36	31.47	−0.032	1.53	16
120	21.65	0.004	0.05	57	34.80	−0.038	7.97**	81				
130	26.04	−0.010	1.16	196	12.21	0.053	5.48*	41				
140	26.50	−0.006	0.24	135	27.84	−0.009	1.49	300				
150					25.00	0	0	10				

Note: df ..... $n_1 = 1$
n_2 = the value shown in the table

*significant at 0.05 level
**significant at 0.01 level

Table 3. The linear regression equations of t_s on y, after stratification of the records according to the power of the boats and to the wave grades.

$$t_s = c_0 + c_1 y$$

Grade of wind wave		2				3				4			
		c_0	c_1	F_c	n_2	c_0	c_1	F_c	n_2	c_0	c_1	F_c	n_2
Main engine (Hp)	220	22.65	0.028	0.81	54	19.84	0.037	7.95**	59	24.46	0.009	0.04	26
	230	24.28	−0.014	0.38	48	17.53	0.075	9.87**	56	15.40	0.090	3.05	26
	250	19.88	0.046	19.36**	280	20.56	0.036	29.52**	304	17.07	0.064	11.53**	154
	270	22.12	0.001	0.01	336	18.40	0.042	29.70**	373	10.19	0.110	44.54**	174
	275	21.06	−0.004	0.06	53	24.23	−0.019	1.62	66	27.70	−0.057	5.14*	27
	290	19.02	0.006	0.18	47	19.86	−0.001	0.01	62	19.72	0.005	0.02	31
	310	17.83	0.042	1.96	51	18.81	0.037	5.58*	55	26.83	−0.036	0.60	31
	320	22.40	0.013	1.22	173	17.20	0.068	80.19**	241	13.39	0.090	16.81**	113
	340	16.98	0.044	1.35	30	16.34	0.053	6.05*	57	18.79	0.020	0.20	27

Grade of wind wave		5				6			
		c_0	c_1	F_c	n_2	c_0	c_1	F_c	n_2
Main engine (Hp)	220	22.91	0.016	0.25	35	18.22	0.048	3.19	46
	230	14.08	0.073	5.53*	43	8.53	0.136	19.14**	48
	250	20.79	0.033	7.26**	224	20.31	0.042	11.55**	248
	270	18.23	0.034	5.54*	266	17.19	0.055	19.50**	280
	275	24.27	−0.015	0.14	35	22.48	0.001	0.0003	41
	290	22.50	−0.021	0.57	38	26.34	−0.044	2.66	43
	310	20.44	0.029	1.06	41	23.78	0.005	0.02	50
	320	18.13	0.052	7.47**	158	17.47	0.066	13.12**	172
	340	19.49	0.020	0.43	45	16.65	0.051	2.41	47

Note: df ..... $n_1 = 1$

n_2 = the value shown in the table

*significant at 0.05 level

**significant at 0.01 level

occurrence of the significant difference of the coefficients (c_1) between the wave grades. The significant difference between the wave grades could be found in one of the types,

Table 4. The results of the *t*-test on the difference of the regression coefficients of t_s on y between the wave grades observable within the same power groups.

Main engine (Hp)		220		230		250		270		275	
		t	*n*	*t*	*n*	*t*	*n*	*t*	*n*	*t*	*n*
Combination of the wave grades	2—3	−0.265	113	−2.546*	104	0.834	584	−3.193**	709	0.649	119
	2—4	0.307	80	−2.047*	74	−0.878	434	−5.405**	510	1.693	80
	2—5	0.252	89	−2.260*	91	0.764	504	−1.869	602	0.301	88
	2—6	−0.443	100	−3.924**	96	0.251	528	−3.319**	616	−0.118	94
	3—4	0.709	85	−0.260	82	−1.586	458	−3.518**	547	0.969	93
	3—5	0.671	94	0.057	99	0.187	528	0.529	639	−0.100	101
	3—6	−0.399	105	−1.537	104	−0.444	552	−0.827	653	−0.527	107
	4—5	−0.126	61	0.315	69	1.430	378	3.397**	440	−0.773	62
	4—6	−0.779	72	−0.766	74	1.024	402	2.647**	454	−1.007	68
	5—6	−0.773	81	−1.403	91	−0.488	472	−1.100	546	−0.277	76

Main engine (Hp)		290		310		320		340	
		t	*n*	*t*	*n*	*t*	*n*	*t*	*n*
Combination of the wave grades	2—3	0.279	109	0.168	106	−3.953**	414	−0.201	87
	2—4	0.041	78	1.416	82	−3.072**	286	0.401	57
	2—5	0.910	85	0.318	92	−1.757	331	0.518	75
	2—6	1.686	90	0.813	101	−2.457*	345	−0.139	77
	3—4	−0.151	93	1.611	86	−0.990	354	0.617	84
	3—5	0.501	100	0.243	96	0.886	399	0.856	102
	3—6	1.238	105	0.894	105	0.143	413	0.048	104
	4—5	0.578	69	−1.252	72	1.285	271	0.009	72
	4—6	1.105	74	−0.685	81	0.819	285	−0.547	74
	5—6	0.582	81	0.513	91	−0.533	330	−0.705	92

Note: *significant at 0.05 level
**significant at 0.01 level

while not observable in the other. The 230, 270, and 320 Hp groups were included in the former, while the boats of the rest in the latter. And all the significant differences were due to the small values of c_1 for the grade 2 in these three power groups or due to the large value for the grade 4 in the 270 Hp group.

The *t*-test on the difference of the coefficients (c_1) between the power groups observable under the same grade of wind wave (Table 5) revealed the following trends: The coefficients (c_1) showed the significant difference in the 40 combinations of the power groups out of 180 ones. In the grade 2, all the combinations of the power groups showing the significant difference were due to the large value for the 250 Hp group; among the 14

Table 5. The results of the t-test on the difference of the regression coefficients of t_s on y between the power groups observable within the same grades of wind wave.

Grade of wind wave	2		3		4		5		6	
Combination of the power groups	t	n	t	n	t	n	t	n	t	n
220—230	1.066	102	−1.422	115	−1.194	52	−1.274	78	−2.099*	94
220—250	−0.641	334	0.057	363	−1.071	180	−0.530	259	0.196	294
220—270	0.967	390	−0.271	432	−2.139*	200	−0.451	301	−0.196	326
220—275	0.912	107	2.748**	125	1.329	53	0.601	70	1.002	87
220—290	0.596	101	1.680	121	0.076	57	0.866	73	2.417*	89
220—310	−0.305	105	0.013	114	0.698	57	−0.299	76	0.973	96
220—320	0.523	227	−1.785	300	−1.615	139	−0.850	193	−0.463	218
220—340	−0.298	84	−0.641	116	−0.174	53	−0.083	80	−0.067	93
230—250	−2.272*	328	2.084*	360	0.513	180	1.219	267	3.216**	296
230—270	−0.535	384	1.468	429	−0.428	200	0.999	309	2.650**	328
230—275	−0.377	101	3.462**	122	2.570*	53	1.748	78	2.727**	89
230—290	−0.735	95	2.587*	118	1.400	57	2.226*	81	4.290**	91
230—310	−1.492	99	1.374	111	1.829	57	1.061	84	2.831**	98
230—320	−1.009	221	0.333	297	0.004	139	0.505	201	1.958	220
230—340	−1.384	78	0.695	113	1.025	53	1.233	88	1.872	95
250—270	3.040**	616	−0.623	677	−1.839	328	−0.026	490	−0.724	528
250—275	2.044*	333	3.565**	370	2.551*	181	1.422	259	1.230	289
250—290	1.498	327	2.258*	366	1.377	185	1.617	262	2.797**	291
250—310	0.131	331	−0.043	359	2.032*	185	0.151	265	1.164	298
250—320	2.053*	453	−3.236**	545	−0.879	267	−0.853	382	−1.129	420
250—340	0.055	310	−0.919	361	0.871	181	0.446	269	−0.273	295
270—275	0.183	389	3.287**	439	3.848**	201	1.211	301	1.530	321
270—290	−0.187	383	2.209*	435	2.664**	205	1.335	304	3.016**	323
270—310	−1.305	387	0.299	428	3.227**	205	0.138	307	1.488	330
270—320	−0.763	509	−2.307*	614	0.737	287	−0.763	424	−0.524	452
270—340	−1.144	366	−0.471	430	1.933	201	0.386	311	0.106	327
275—290	−0.462	100	−0.750	128	−1.344	58	0.116	73	0.941	84
275—310	−1.411	104	−2.584*	121	−0.391	58	−0.905	76	−0.082	91
275—320	−0.695	226	−5.275**	307	−3.234**	140	−1.535	193	−1.589	213
275—340	−1.358	83	−2.812**	123	−1.501	54	−0.705	80	−0.982	88
290—310	−1.071	98	−1.590	117	0.702	62	−1.253	79	−1.103	93
290—320	−0.264	220	−3.914**	303	−2.000*	144	−1.686	196	−2.918**	215
290—340	−1.065	77	−1.941	119	−0.266	58	−0.969	83	−2.237*	90
310—320	0.933	224	−1.854	296	−2.589*	144	−0.575	199	−1.572	222
310—340	−0.040	81	−0.619	112	−0.860	58	0.219	86	−0.959	97
320—340	−0.843	203	0.786	298	1.409	140	0.818	203	0.371	219

Note: *significant at 0.05 level
**significant at 0.01 level

combinations in the grade 3 showing the significant difference, the 13 were due to either the small values for the 275 Hp group and the 290 Hp group or the large value for the

Table 6. Number of the combinations of the power groups showing significant difference of the regression coefficients of t_s on y under respective grades of wind wave.

Maine engine (Hp)		220		230		250		270		275		290		310	
		L	S	L	S	L	S	L	S	L	S	L	S	L	S
Grade of wind wave	2				1(1)	4(4)			1(1)		1(1)				
	3	1(1)		3(2)		2(2)	2(1)	2(2)	1(1)		7(7)		4(4)	1(1)	
	4		1(1)	1(1)		2(1)		4(4)			4(4)		2(2)		3(2)
	5			1									1		
	6	1(1)	1(1)	6(6)		1(1)	1(1)	1(1)	1(1)		1(1)		6(6)		1(1)
Sum		2	2	11	1	9	3	7	3	—	13	—	13	1	4

Grade of wind wave	320		340		Sum	Remarks
	L	S	L	S		
2		1(1)			4(4)	All the significant differences were due to the large value in the 250 Hp group.
3	4(4)		1(1)		14(13)	Most of them were due to the small values in the 275 and 290 Hp groups or due to the large value in the 320 Hp group.
4	3(3)				10(9)	Most of them were due to the large value in the 270 and 320 Hp groups or due to the small value in the 275 Hp group.
5					1	
6	1(1)		1(1)		11(11)	All the significant differences were due to the large value in the 230 Hp group or due to the small value in the 290 Hp group.
Sum	8	1	2	—	40	

Note: x (y) ..... x is the number of combinations showing significant difference out of eight ones; y that due to the reason shown in the remarks (the value of y is included in x).
L ..... significantly larger than the coefficient for other power groups.
S ..... significantly smaller than that for other power groups.

320 Hp group; the 9 combinations out of 10 showing the significant difference in the grade 4 were either due to the large values for the 270 Hp group and the 320 Hp group or due to the small value for the 275 Hp group; and all the 11 combinations showing the significant difference in the grade 6 were either due to the large value for the 230 Hp group or due to the small value for the 290 Hp group. Namely, among the 40 combinations of the power groups showing the significant difference in c_1, the 38 combinations (a combination in the grade 5 was not counted in the description but included here) were due to either the large values in the 230, 250, 270, and 320 Hp groups or the small values in the 275 and 290 Hp groups.

Discussion

The examination through the multiple linear regression equations showed that the regression coefficient on the depth (a_1) was insignificant in both of the extreme grades of wind wave and that on the power (a_2) was insignificant in the wind wave grades 1,5 to 7. The former fact may be because of the following reasons: Most of the days fished were in the range of the wind wave grades from 2 to 6. And the days in the grade 7 were observable just after the arrival of the fleet at the fishing ground; and the sea was so calm as in the grade 1 only on few of the days in the midsummer. The sample sizes of these grades were, accordingly, smaller than those in the other grades. But this fact could not be the sufficient reason to make the regression coefficient on the depth (a_1) insignificant, because even the sample size of these grades was still sufficiently large. The fleet fished pursuing the seasonal bathymetric migration of the objective fish. The days either in the grade 1 or in the grade 7 were observable within limited seasons. This fact resulted in the small depth-variation, which made the regression coefficient on the depth (a_1) insignificant. The days in the other grades were observable throughout the season. This resulted in the large variation of the depth fished, which made the regression coefficient (a_1) significant. The sinking-pulling time can be divided into the time of waiting for the net and warp to sink down and that for pulling together the warp. During the time of waiting for the net and warp to sink down, the engine was not in use. The warp and net start to sink down as soon as they are laid in water. If the laying speed differed in accordance with the power of the boat, the influence of the different speed of laying had to be taken into consideration. But the laying time had no relation to the power[7]. It is natural, accordingly, that the time to waiting for the net and warp to sink down has no relation to the power of the boat. The influence of the power on the sinking-pulling time is to be that on the time for the pulling work. The boats were constructed suitable for fishing in far deeper waters than in the present case, but they were in the present case legally restricted within the grounds of not deeper than 150 m. This meant that they worked in the present case with sufficient surplus of the power. They pull together the warp receiving the wind from aft. The skipper believes that pulling the warp at too high speed is unfavorable to concentrate effectively the fish with the approaching barrier of the noise and cloud of mud raised by the rubbing of warp with sea bed. And the pulling speed is regulated, especially when the wind from aft is strong. This made the power less influential on the pulling time, or in other words a_2 insignificant, when the wind was strong and the height of wind wave was in the grades 5 to 7. The regression coefficient on the depth (a_1) under the wind wave grade 1 took the similar value to the others although in the opposite sign. But it was insignificant because of a large within-depth-class variation of the time. And it was hard to find the factors probably responsible for it.

As above mentioned, the boats fished with sufficient surplus of pulling power and pulled the warp at regulated speed. But the following results in the preceding report and the multiple linear regression equations suggested that the influence of the power on the time for this step of work differ in accordance with the depth of fishing ground and its combination with the wave grades: The boats expended longer time in the deeper ground [3] and in windy days [5]; and the powerful boats expended shorter time on this step of work than the less powerful ones [7]. But the stratification of the records into the depth-wave grade groups made the regression on the power (b_1) insignificant in most of the groups. There was at least one depth zone in each of the wave grades showing significant regression on the power; but their distribution had no relation to the wave grade. These results made it hard to examine the probable difference in the influence of the power between the different combinations of the depth with the wave grades–between shallow zone in calm days and deep zone in windy days or between shallow zone in windy days and deep zone in calm days. But they suggested that the significant regression on the power found in the preceding report [7] and in the multiple linear regression equations should be due to the same trend in few of the depth zones or due to the bathymetric segregation of the boats. Namely, if a less powerful boat inclined to fish in deeper grounds than a powerful one, the depth regression resulted in a less powerful boat expending longer time than a powerful one before the stratification of the records into the depth zones but insignificant after it. The supposition like this was rather contrary to our natural way to use the fishing boats, and was denied by the small within-day variation of the fishing depth found in the original records. It is natural that the fact making it difficult to find the regression on the power (b_1) is the sufficient surplus of the power. This makes the boat pulling the warp at regulated speed. And the difference in the time for this step of work does not indicate the difference in the pulling speed at full of the power but rather means the difference between the speed regulation and the influence of the factor under consideration. In such a case as this, there is much risk of being suffered from the influence of such a factor as the individuality of the boat. The representatives of this group of factors are the temperament of the skipper, the preference to the pulling speed, its change with depth, the boat-by-boat difference in the relation of the power of main engine to the pulling power, the wind drift of the boat with the wind from aft, the different understanding and way of the adjustment to these factors, etc. The difference in the construction of the net and the length of warp may be included in them; but this possibility was denied in the present case, because the boats used the net of the same construction supplied by the factory ship and used the warp of the same length.

With an intention to give further consideration getting rid of the influence of this group of factors, the records were stratified according to the power of the boats; and the linear regression equations of the sinking-pulling time on the depth fished observable under respective grades of wind wave were estimated. Then the difference in the coefficients (c_1) between the wave grades was examined through the t-test. The results showed that the significant regression on the depth (c_1) could be found chiefly in the four power groups. The sample size was large in three of them but small in the rest (230 Hp group). The difference of the coefficients (c_1) between the wave grades was significant in three of them, but insignificant in one of the groups of large sample size (250 Hp group). And all the significant differences of c_1 between the wave grades were responsible for the large value of the grade 2 in three of the power groups and the small value of the grade 4 in one of them. But whether a boat took small (or large) value in these grades or not had no relation to the power. These facts casted a doubt on the difference of the boats in respect of the occurrence of significant regression on the depth (c_1) and of the significant difference between them being due to the sample size or due to the difference in the power, but suggested that they should be due to the individuality of the boats.

A trial to pursuing the influence of the individuality of the boats observable in the relation of the sinking-pulling time to the depth was carried out through the comparison of c_1 between the power groups. And the following trends could be found out: Most of the significant differences in c_1 between the power groups were due to the large values in some of the power groups or due to the small values in some other ones. And the boats taking smaller (or larger) value of c_1 in a grade of wind wave than the other boats inclined to take smaller (or larger) values in the other wave grades. But whether a boat or a group of boats took a large value of c_1 or not had no relation to its power. These trends may be due to the fact that the boats pulled the warp with a regulated power, because they were constructed suitable for fishing in deeper grounds than in the present case. These facts also suggested the possibility of the individuality of the boats being more influential than their power in respect of the difference in c_1.

Conclusion

From all the results shown in the present and the preceding reports, it may be said that ———

The most influential factor on the sinking-pulling time among those examined here was the individuality of the boats. This fact made the regression on the power insignificant in most of the depth-wave grade groups. A boat (or a group of boats) taking smaller regression coefficient on the depth than the others in a wave grade inclined to take smaller values in the other wave grades. The same fact made it hard to find any clear relation between the power and the regression coefficient on the depth. These trends prevented us from examining whether the influence of the depth differed in accordance with the power or not and vice versa.

Summary

With an intention to give a collective consideration on the time expended on the sinking-pulling steps of work observable in the records of the work of Danish seiners during the Alaska Pollack fishery in 1964, the multiple linear regression equations of the time on the depth fished and on the power of the boats and the linear regression equations of the time either on the power or on the depth fished were estimated after stratification

of the records according to the grade of wind wave and according to the depth or to the power. Then their coefficients were compared with one another. And the trends found out were summarized as follows:

1. The multiple linear regression equations showed that the sinking-pulling time increased in accordance with the depth fished at a rate of from 1.4 min. to 7 min. per 100 m increase in the depth fished but decreased with the power at a rate of from 0.9 min. to 2.3 min. per 100 Hp increase in the main engine.

2. The regression of the sinking-pulling time on the power of the boats was significant in the eight depth-wave grade groups out of 41 ones; but the distribution of these significant coefficients had a relation neither to the grade of wind wave nor to the depth fished.

3. The significant regression of the sinking-pulling time on the depth could be found chiefly in the four power groups out of nine ones.

4. The significant difference of the regression coefficients on the depth between the wave grades could be found in the three power groups out of the above-mentioned four.

5. Most of the significant differences in the regression coefficient on the depth between the power groups were due to some extreme values observed in some of the power groups.

6. A boat (or a group of boats) taking a smaller (or larger) regression coefficient on the depth than the others in a wave grade inclined to take also smaller (or larger) values in the other wave grades.

7. But clear relation could not be found between the power of the boats and the following three points: whether the regression coefficient on the depth in a group of boats was significant or not, whether the significant differences of the coefficients of a boat between the wave grades could be found or not, and whether the coefficient was smaller (or larger) than that of the other boats or not.

8. All these trends may be due to the fact that the boats were constructed suitable for fishing in deeper grounds than in the present case and they pulled the warp with a regulated power.

References

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