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YEARLY VARIATIONS IN THE RELATIVE CATCHABILITY OF THE FISHING VESSELS
OPERATING WITH THE MOTHERSHIP POLLOCK FISHERY IN THE EASTERN BERING SEA
Yoshiya TAKAHASHI

Bull. Far Seas Fish. Res. Lab., No. 10, June 1974.

The volume of fish resources is usually estimated on the basis of catch per unit of fishing effort. However, as was pointed out by Treschev (1973), confusion arose due to inadequacy in expressing the quantity of fishing effort. Take, for instance, trawling at a certain fishing site; the fishing performance is determined by the following two groups of factors: (1) the characteristics and the structure of the net, i.e. the width at the mouth, the height, the size, the quality of netting twine, the size of mesh, etc., (2) the hauling power and speed of the vessel. However, the units used in general for expressing the amount of fishing effort are, for example, "one net haul" and "one-hour haul". There is no reference to the characteristics of the nets or to the speed of the vessels hauling them. As the vessels become larger in size each year, if the quantity of catch per unit effort changes annually, it is necessary to standardize the quantity of fishing effort.

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If the definition of "catchability" is as was defined by Ricker (1958) that is "the ratio of the quantity of the catch with a given quantity of fishing effort units, to the total resource volume", then standardizing the quantity of fishing effort consists simply in comparing, in common measures, the "catchabilities" of vessels of a certain size equipped with a certain fishing gear, by "one net haul" or "one-hour haul". In order to do this, the best way is to operate "the vessels and the gear system simultaneously on the same fishing ground and to compare the quantities of their catch.

However, it is impossible to operate the vessels and the gear systems on the same fishing ground at the same time. Therefore, fishing statistics sharing some common features (for example, the width of the fishing grounds) have to be used in order to obtain the necessary standardization of fishing effort quantity. When fishing statistics are used, depending on the kind of statistics, the influence of factors other than fishing performance, but included in the fishing operations which are a commercial enterprise, is apparent in the amounts of catch to be compared. For example, the following factors are said by Shindo (1969) to determine the fishing efficiency when measured by the catch volume of one journey: (a) Ability to select fishing sites (This depends on the communication facilities for the exchange of information on fishing conditions, fishing grounds such as radio and telephone and on the apparatus to determine the fishing positions such as the Loran or echo sounder).

(b) Ability to find schools of fish at a fishing site (i.e. fish finder). (c) Fishing capability (tonnage, horsepower fishing gear, etc.) (d) Others (skipper's leadership, etc.). Treschev (mentioned above) proposed a new method of expressing "fishing power" and "fishing effort" by the physical properties characteristic to the fishing gear. Treschev mentions three factors determining "fishing effectiveness".¹ (a) The volume of water running through the fishing gear. (b) The ability to find a school of fish: the ratio of the number of fish in the water running through the net to the total number of fish at the fishing site at fishing time. (c) The ratio of the number of fish in the catch to the total number of the fish in the water² going through the nets.

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The mothership pollock fishery in the eastern Bering Sea developed rapidly since about 1965. Meanwhile the size of fishing vessels increased, the fishing gear improved, and the efficiency of fishing vessels increased in a short period of time. In this research on the average yearly variation in the relative "catchability" of fishing vessels the "catchability" in one net haul or one-hour haul by a fishing vessel and its gear system is called "the catchability of that vessel".

¹ The statement concerns the ability to discover schools of fish. Therefore it must be referring to the fishing operation which is selectively done within a fishing ground of a given size.

² Treschev calls the ratio "Catchability of gear (q)".

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Fishery Situation

Pollock fishing in the eastern Bering Sea began when the mothership trawl fishery changed its target species about 1965 from yellowfin sole intended for fishmeal to pollock intended for frozen mince. The fishery situation around that time is clear from the volume of catch by trawling in the eastern Bering Sea shown in Figure 1 and Table 1.

Aside from the above-mentioned mothership trawlers, the northern trawl fisheries³ use also since 1968 large-size trawlers of 3,000-6,000 tons which operate independently of each other, to fish pollock in the eastern Bering Sea. However, mothership fishing usually represents more than 70% of the total operation (Table 1).

³ Northern trawl fishing means trawl fishing conducted in the Bering Sea in the north Pacific Ocean, east of 170° E longitude and north of 10° N latitude. The offshore transfer of catch is permitted. The vessels operated for this fishing are stern trawlers of 500-6,000 tons. There are 42 licensed vessels.

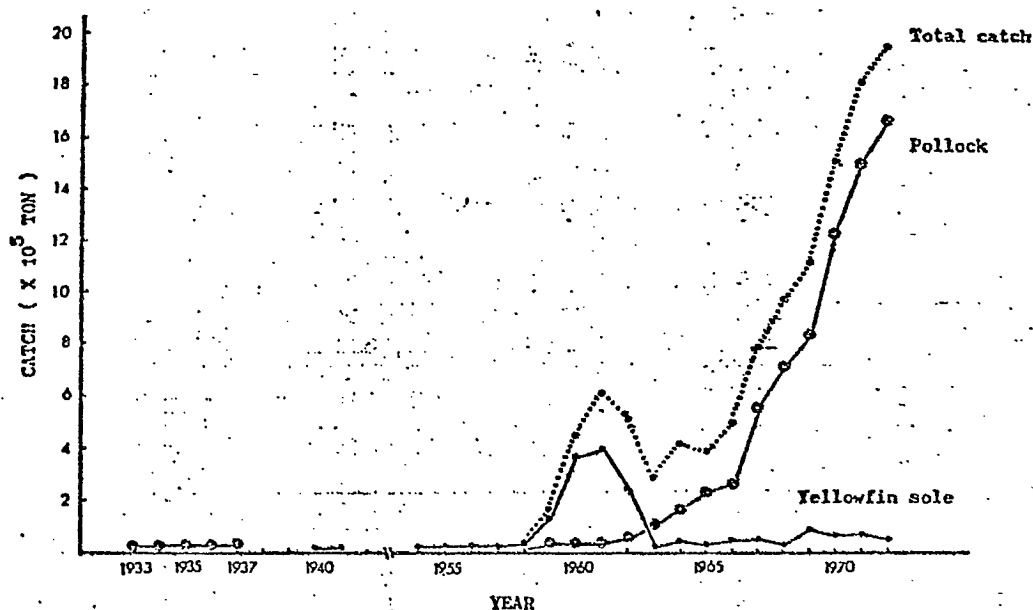


Fig. 1. Change of the annual catch of the Japanese groundfish in the Bering Sea, 1933 to 1972.

Table 1. The catch of Japanese mothership and North Pacific Trawl Fisheries in the Bering Sea, 1960-72.¹⁾ (100 metric ton)

Year		1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
Total catch	Total	4,500	6,278	5,046	3,136	4,243	3,980	4,474	7,501	8,629	10,757	14,244	17,262	18,472
	Mothership { Mince, fishmeal fleet	4,103	4,763	4,082	1,445	3,056	2,843	3,199	6,328	7,325	7,842	11,109	11,603	12,060
	Fishery { Freezing fleet	397	1,464	903	1,600	1,089	981	1,133	1,062	420	676	506	726	813
North Pacific Trawl Fishery		—	51	61	91	98	156	142	111	884	2,239	2,629	4,933	5,599
Pollock	Total	261	245	595	1,138	1,754	2,288	2,652	5,483	6,672	8,410	12,029	14,912	16,490
	Mothership { Mince, fishmeal fleet	261	241	573	895	1,736	2,255	2,555	5,353	6,398	6,713	10,073	10,744	11,443
	Fishery { Freezing fleet	—	3	22	242	17	23	85	110	5	157	27	7	106
North Pacific Trawl Fishery		—	1	—	1	1	10	12	20	269	1,540	1,929	4,161	4,941
Yellowfin sole	Total	3,601	3,996	2,533	211	515	287	458	580	283	671	629	700	435
	Mothership { Mince, fishmeal fleet	3,370	3,863	2,507	209	486	247	371	454	131	566	228	156	10
	Fishery { Freezing fleet	231	126	26	2	29	39	87	126	113	85	301	408	356
North Pacific Trawl Fishery		—	7	—	—	—	1	1	—	39	20	100	136	69
Others	Total	638	2,037	1,918	1,787	1,974	1,405	1,364	1,438	1,674	1,676	1,586	1,650	1,547
	Mothership { Mince, fishmeal fleet	472	659	1,002	341	834	341	273	521	796	563	808	703	607
	Fishery { Freezing fleet	166	1,335	855	1,356	1,043	919	961	826	302	434	178	311	351
North Pacific Trawl Fishery		—	43	61	90	97	145	129	91	576	679	600	636	589

1) 1960-1963 and North Pacific Trawl Fishery in 1964-1967, calendar year (TAKAHASHI, 1972).
1964-1972, fishing year (from November of the previous year to October of this year; by catch statistics of Far Seas Fisheries Research Laboratory).

Mothership fishery can be divided into two categories according to target species and methods of processing fish; i.e., (1) the mince fleet which catches pollock and processes it into frozen mince and (2) the freezing fleet which catches and freezes herring, halibut, Alaska cod, Alaska ocean perch, etc.

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A large-size vessel of 10,000-30,000 tons is used as factory ship (mothership) in a mince fleet. The 10-30 vessels attached to one mothership are bull trawlers (pair trawlers), Danish trawlers (seiners) and otter trawlers (side and stern trawlers). On board of a mothership conducting pollock fishing, production of frozen mince, of fishmeal or of fillet is carried out. Species other than pollock are rarely catch targets in this operation except for those which are accidentally caught together with pollock (Table 1).

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The four types of fishing used are pair trawling, Danish seine, side trawling and stern trawling. They are used on different fishing grounds. The first two are adopted on the continental shelf and the latter two on the slope of the continental shelf. If otter trawling is used on the continental shelf instead of pair trawling and Danish seine, the fishing efficiency decreases.

One fleet usually operates within a radius of approximately 20 miles from the mothership, and the vessels attached to a mothership deliver daily their catch to that mothership except for two vessels which at time are dispatched far away in search for fish schools. Fishing sites are selected on the basis of the fishing patterns of the vessels attached and of the reports from the search vessels providing information concerning the water temperature distribution

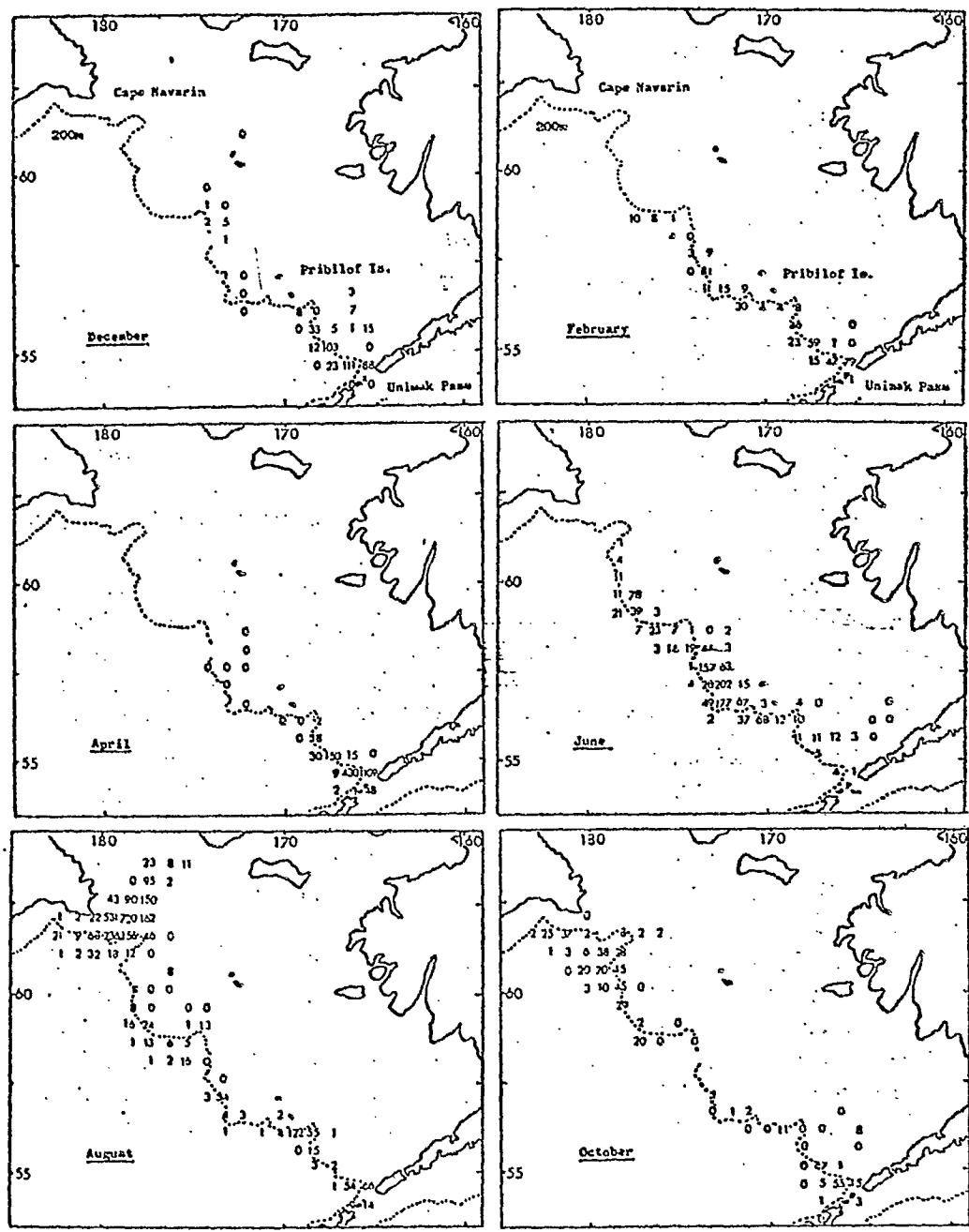


Fig. 2. The distribution of the pollock catch, by two month, in the eastern Bering Sea, during the year from December in 1971 to October in 1972. (Unit of catch: 100 metric ton).

and the presence of pollock. In general, the fishing grounds are on the continental shelf and its slope between the Unimak Pass and the Pribilof Islands in winter and spring from November to May but move gradually to the north along the edge of the continental shelf between the Pribilof Islands and Cape Navarin in summer and autumn from June to October (Figure 2).

Yearly Variations in the Tonnage of Vessels

The numbers of satellite vessels in a mince fleet by different classes of tonnage are shown in Table 2, according to years.

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Table 2. The number of vessels operated in the mothership pollock fishery in the Bering Sea, by gear and by gross-tonnage, 1965-1972¹⁾.

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Gross-tonnage	Pair trawler								Danish seiner							
	1965	1966	1967	1968	1969	1970	1971	1972	1965	1966	1967	1968	1969	1970	1971	1972
50										1						
60									5	3						
70									23	11	2					
80									36	39	28	12	6	4	2	1
90	4	8	4	4	2	2			4	4	11	10	7	5	4	3
100	2	2							3	8	16	35	43	49	41	31
110	6	6	14	8	8	6	4	4					1	2		
120	4	4	6	4	2				2				1	4	6	10
130									2				2			
140									2		1					
170			4	4	2	4	3	2								
180				2	2	6	13	12								
190				4	2	10	18	20	1							
200								4		1	2					
210								6								
270											2					
280											2					
290											2					
300									1	1	7		2	1	1	1
Total	16	20	28	26	18	28	38	48	81	68	73	57	62	65	54	46
Average ²⁾	106.3	103.0	117.9	135.4	132.2	160.7	176.6	183.3	81.6	80.0	89.1	94.0	98.3	99.5	100.8	103.3

1) Including the figures reported from the fishing companies. There are some discrepancies between the catch statistics of the Far Seas Fisheries Research Laboratory.

2) Average tonnages of Danish seiner are for the vessels less than 150 ton, and the ones of side trawler and stern trawler are for the vessels less than 500 ton.

Table 2. Continued.

Gross tonnage	Side trawler								Stern trawler							
	1965	1966	1967	1968	1969	1970	1971	1972	1965	1966	1967	1968	1969	1970	1971	1972
270	1	2														
290	2	2														
300	3	3							1	1	12	8	7	7	7	8
310			7							4	8	2	4	2	2	3
320						1	3									
350	1	1										1	1	3	2	3
360										1						
370	11	9	5	1	1	2										
500														5		1
540			1	1												
550								1								1
Total	18	17	13	2	2	5	—	1	1	6	20	11	12	17	11	16
Average ²⁾	342.8	335.9	335.0	370.0	345.0	340.0	—	—	300.0	316.7	304.0	306.4	307.8	314.2	310.9	312.9

The tonnage of all the pair trawlers operated between the years 1965 and 1966 is 90-120. However, most of those operated between 1971 and 1972 are 170-210 in tonnage. The average tonnage increases over the years from 106 in 1965 to 183 in 1972.

The tonnage of most Danish seiners is in the range of 50-140 tons but there is each year an increase within that range. Some large-size vessels of more than 150 tons are used. These vessels are of the type which appeared around the time the size of "hokuyo tenkansen" (the North Sea Transfer vessel)¹ began to increase, but before stern trawlers with two-storied decks began to be used. The vessels of this model have grown few lately.

¹ "Hokuyo tenkansen" means a trawler operating independently in the area east of 153° E and west of 170° W longitude and north of 48° N latitude. Offshore transfer of catch is not permitted. There are 182 licensed vessels. Among them some are used in the mothership fishing for a certain period of time.

Side trawlers of about 300-370 tons were used in the years 1965-1966. Since then, however, they have been replaced by stern trawlers with a better efficiency.

Since 1967, the number of stern trawlers increased. Many of them are of the 299 ton type and the 349 ton type of the North Sea Transfer vessels. The tonnage of the North Sea Transfer vessels is restricted to a maximum of 350. As the size of this type of vessel already nearly reached the maximum, the tendency to become each year larger in size is no longer noted.

Relation between the Tonnage of Fishing Vessels
and the Horsepower of the Engines

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The horsepower of the engines of fishing vessels is usually expressed in the so-called "agriculture and forestry" horsepower (Nominal horsepower category). It is obtained by an established formula for the purpose of determining the number of engineers. All horsepowers mentioned in this paper are "Shaft horsepower" that is "the net power output which the motor and all other machines transmit" (Tennensha, 1951). Although it was not possible to find the value of shaft horsepower for all the fishing vessels listed in Table 2, it was possible to determine it for more than half of them. From the values obtained, the relation between the gross tonnage of those fishing vessels and the horsepower of their engine was investigated. The data according to year, fleet and tonnage are shown in the appended tables at the end of this paper.

The relation between the tonnage and the horsepower varies according to the type of vessel. There is a tendency for the type of fishing vessels operated to differ each year by trial and error. Therefore, when the relation between the gross tonnage and the horsepower is shown on a diagram, some ships show a divergent correlation. (Figures 3-5). These are most likely the types abandoned in the trial and error process. There is a problem of how to deal with these types in studying the relation between tonnage and horsepower. In this research, we made two different calculations regarding the pair trawlers: one including all types, the other excluding the abandoned ones. Abandoned types were excluded from the Danish seiners and side trawlers. The horsepower was observed to increase rapidly as the tonnage increases as seen in Figures 3-5; so the following formula was used to show their relation.

$$Y = ab^X \dots \dots \dots (1)$$

Y is the horsepower (100 horsepower unit).

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X is the gross tonnage (100 ton unit).

The values of constants a and b are shown in Table 3 by method of fishing. The curves obtained from the calculation by using the estimated values of a and b are shown in Figures 3-5.

Table 3. The values of the constants of the formula, $Y=ab^X$, expressing the relationship between the gross-tonnage and the horse power of engine of the fishing vessels operated in the mothership pollock fishery in the Berjng Sea, 1965-1972.

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Y is shaft horse power of engine (100 PS) and X is gross-tonnage (100 ton) of the vessel.

Genr	Constant	
	a	b
Pair trawler (1)*	0.8720400	3.4813451
(2)	0.8205468	3.6541633
Danisk seiner	0.4208241	12.6310347
Side trawler	1.6025370	1.5095032
Stern trawler	7.7784161	1.1649323

*: See Fig. 3.

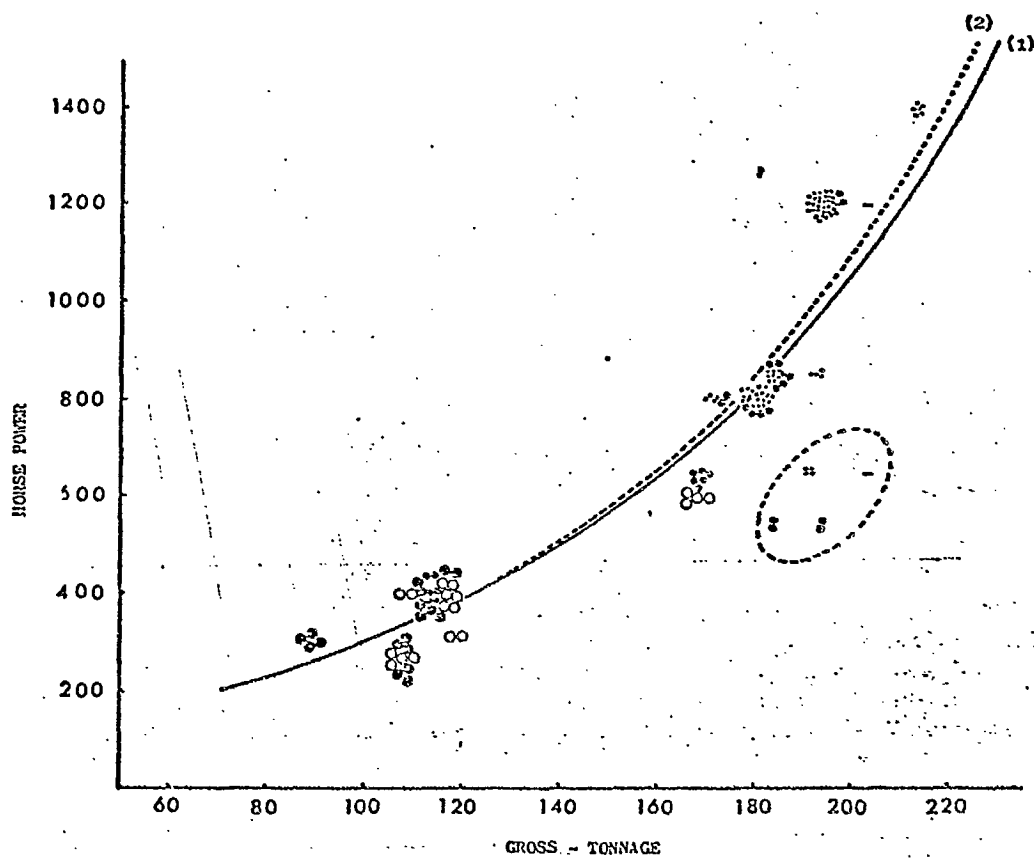


Fig. 3. The relationship between the gross-tonnage and the horse power of engine of the pair trawlers in the mince mothership-fleets in the Bering Sea, 1965-1972.
Regression curve (1) includes all the points and regression curve (2) excluded the circled points.

- : 1965-66
- : 1967-68
- : 1969-70
- : 1971-72

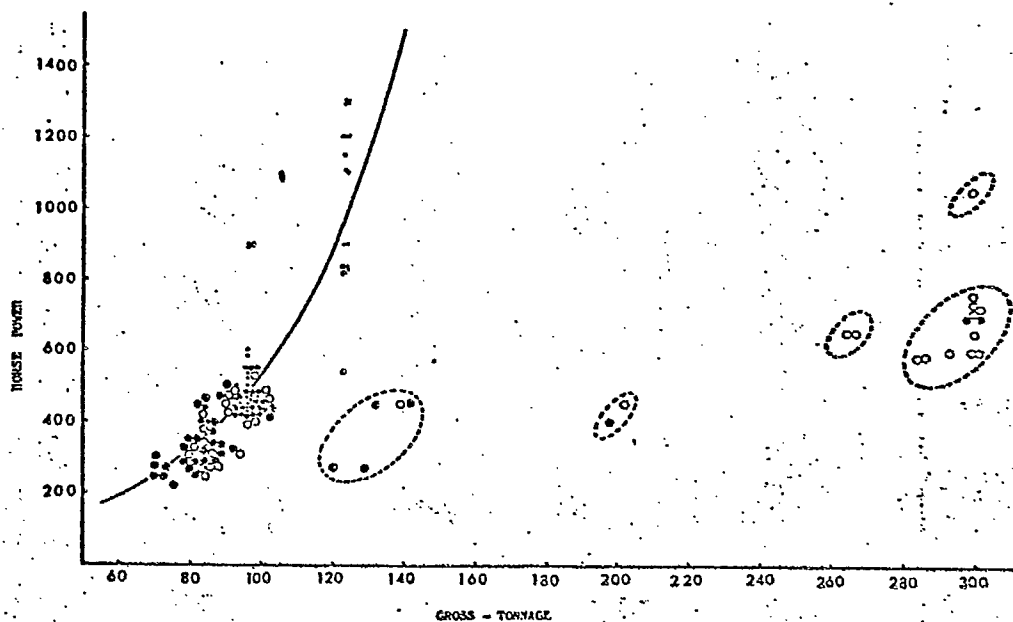


Fig. 4. The relationship between the gross-tonnage and the horse power of engine of the Danish seiners in the mince mothership fleets in the Bering Sea, 1965-1972. Plots are one third of all the data smaller than 100 ton and are all the data larger than 100 ton. The circled points are excluded from the calculation of the regression curve.

⊙ : 1956-66

○ : 1967-68

● : 1969-70

• : 1971-72

Gross Tonnage and size of Fishing Gear

The structure of the trawl nets used varies according to each fishing company. In this paper, according to data obtained by oral survey with respect to the nets used by a total of 69 vessels belonging to a mince fleet, the size is indicated by the length of the head rope (from the middle of the head rope to the extremity of the cod end), of the grand rope and of the main net, and the average value is shown according to the tonnage class of the fishing vessels (Table 4). It is obvious from this table that the nets used increase in size as the tonnage increases.

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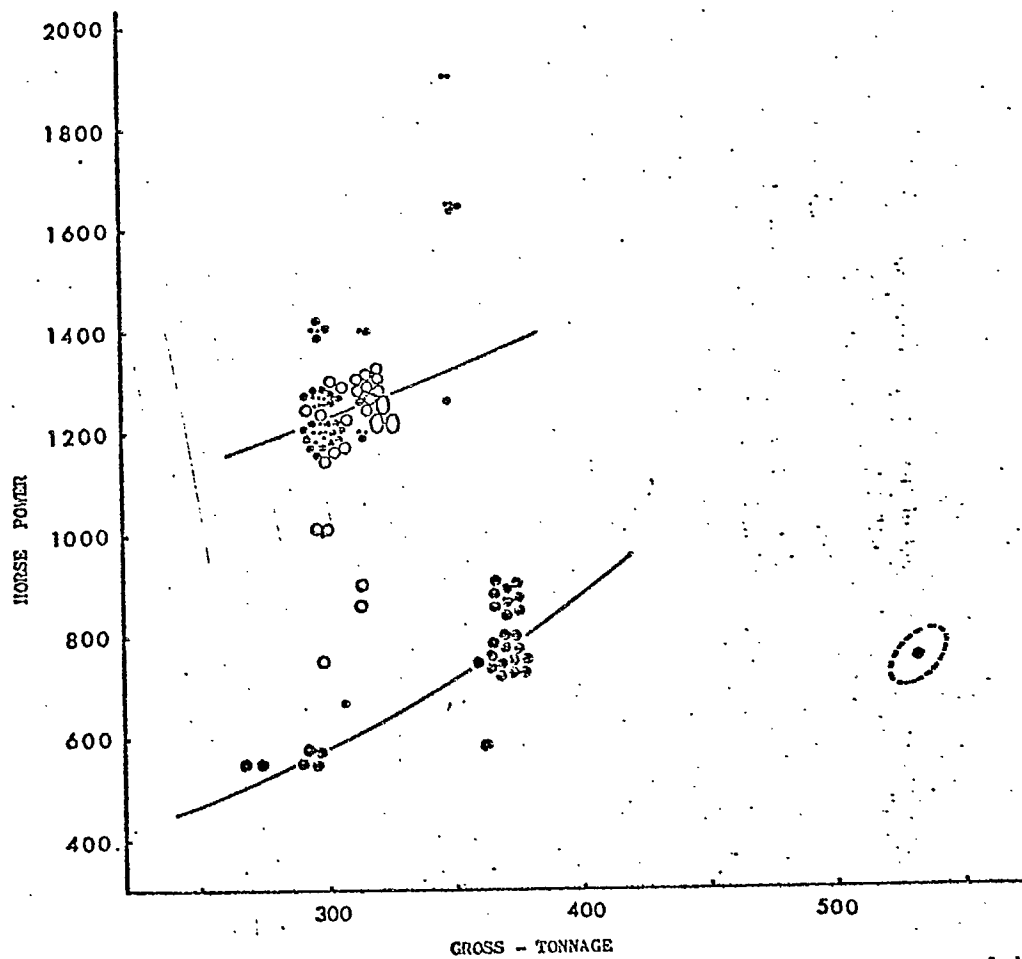


Fig. 5. The relationship between the gross-tonnage and the horse power of engine of the side trawlers and stern trawlers in the mince mothership fleets in the Bering Sea, 1965-1972.

The circled point is excluded from the calculation of the regression curve.

Stern trawler	{	○ : 1965-66
		○ : 1967-68
		● : 1969-70
		• : 1971-72
Side trawler	⊙ : 1965-67	

Table 4. The relationship between the tonnage and the size of trawlnet of the fishing vessels operated in the mince motherships, A, C, D, and E¹⁾, in the Bering Sea in 1958.

Gross tonnage	Pair trawler			Danish seiner			Side trawler			Stern trawler				
	No. of vessels sampled	Length of head- rope (m)	Length of grand- rope (m)	Length ²⁾ of the body of net (m)	No. of vessels sampled	Length of head- rope (m)	Length of grand- rope (m)	Length ²⁾ of the body of net (m)	No. of vessels sampled	Length of head- rope (m)	Length of grand- rope (m)	Length ²⁾ of the body of net (m)		
80				7	83	92	34							
90				10	82	89	38							
100				24	88	97	38							
110	4	70	78	41										
120	2	70	78	41										
170	4	89	97	49										
190	6	123	130	55										
300				1	108	117	51				7	47	57	33
310											1	53	60	43
350								1	53	60	43			
360								1	47	57	33			
370								1	47	57	33			

1) Names of mothership, see the Appendant table.

2) From the center of the head-rope to the terminal of the cod-end.

Relation between the Horsepower and the Relative

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Catchability of Fishing Vessels

If the hull of trawlers becomes larger, the horsepower of the engine increases as well as the hauling power of fishing vessels. Then larger nets will be used which will make it possible to increase the trawling speed so that the catchability of the vessel will increase. (Yamada, 1969; Sengoku, 1971; Treschev, 1973).

As was already mentioned, the ideal way to compare the catchabilities of fishing vessels is to operate the vessels simultaneously at the same fishing site and compare their catch.

Although the catch volumes per unit effort reported in this paper are compared among different horsepower classes, the data used are not based on the strict application of the condition that "the fishing vessels be simultaneously operated at the same site."

It was inevitable that a considerably wider range of "area and time" would have to be used. As a result, the catch volume per unit effort listed in this paper is affected by the following factors. (a) The density of pollock resources, (b) the catchability of the vessels, (c) the ability to select fishing sites, (d) the ability to find schools of fish at fishing sites, and (e) the skipper's leadership. Since the catchabilities mentioned in (b) are to be compared, it is desirable that the remaining factors be common to all the vessels.

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As mentioned above, with mothership fishing, unlike other types of fishing carried out by single vessels, vessels belonging to a fleet operate within a radius of approximately 20 miles from the mothership. The wages of the crew to a certain extent correspond to the catch of each vessel. Therefore, the operations of the vessels around the mothership are highly competitive. As a result, differences in factors (c), "ability to select fishing site", are observed between fleets (Table 5).¹ In regard to factor (d), "ability to find schools of fish at fishing sites", if it means the capacity

¹ There is a difference in the estimation of the catch depending on whether the fishing vessel had a charter period contract or a purchase contract with the mothership. Lower figures are reported in the latter case.

of the fish finder and of the equipment there is not much difference between vessels. Concerning factor (e), "Skipper's leadership", differences are observed among vessels in many cases of fishing operation. However it is difficult to evaluate this ability separately from the other abilities mentioned in (c) and (d). In general, however, a good vessel of a new type has an able skipper aboard. Therefore, the catchability of a large vessel may tend to be overestimated. Factor (a), "the density of pollock resources", changes of course with the time.

In this paper, therefore, a given journey of a certain fleet is considered as one block, and within this block the volumes of catch per effort unit with respect to horsepower strength are compared among the vessels. In other words, the satellite vessels of each fleet are grouped into classes according to the engine horsepower, and the average values of catch volume per effort unit in one journey are compared between classes. The horsepower is grouped into units of 50 in the case of pair trawlers and Danish seiners, and of 100 in the case of otter trawlers. The class that has the greatest number of vessels and many years of fishing experience is regarded as the standard class and the ratio of catch to effort in that class is considered to be the relative catchability.

The horsepower of the standard class in pair trawlers is 475 in Danish seiners, 750 in side trawlers, and 1,250 in stern trawlers. As fishing vessels increase in size every year, a second standard class is set for the classes that did not have the same operating conditions as the standard class in regard to which their

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Table 5. The average catch per effort of the fishing vessels with various horse power of engine. The calculations were done by gear, by horse power of engine, by fleets, and by voyages. A-F show the fleets from which the figure has got.

Horse power of engine (PS)	Pair trawl (ton/one hour haul)						Danish seine (ton/a set)							
	1966	1967	1969	1970	1971	1972	1965	1966	1967	1968	1969	1970	1971	1972
225							A(2.92) B(5.46)							
275		C(7.46)					A(3.58) A(3.96) C(6.06) E(5.34) E(7.01) B(6.01) B(3.96)							
325	A(5.60)	C(8.07)					A(3.95) A(3.91) C(6.26) E(4.79) B(5.35) B(3.88)							
375		C(9.78)		C(7.81)			A(2.99) A(3.19) E(5.49) D(6.89) E(6.13) E(6.70) E(5.58)							
425			D(8.88)				A(3.79) B(3.67) C(6.09) E(6.09) D(6.79) C(6.91) E(5.74) C(6.50) B(8.53) E(5.40) D(6.18) F(4.96) E(5.87)							
475							E(6.16) D(7.91) C(9.90) D(6.42) C(6.73) E(6.29) D(5.04) E(6.13) D(5.81) E(8.52) F(6.93) F(6.12)							
525				C(20.06)			D(7.52) C(9.58) D(7.50) C(6.60) D(7.00) F(7.35) D(4.75) F(6.88)							
575							E(6.60) E(6.44) D(7.25) E(5.89) E(7.14)							
625		D(14.87)	D(12.01)	E(15.72)	E(15.39)									
775			E(27.02)	E(16.17)	E(15.19)									
825		D(18.55)	D(16.70)	D(11.45) C(14.94) F(12.02) D(16.42)						D(9.68)	D(9.34)	D(8.08)	F(8.24)	
875										D(6.84)	D(8.17)	D(6.91) F(6.88)	F(7.11)	
1,075												F(5.81)	F(5.50)	
1,125														C(7.52)
1,175			D(15.16)	D(13.09)	C(21.08) F(13.25) D(20.88) F(16.64)							F(8.39)	F(8.40)	
1,275														C(6.25) D(8.13)
1,375							C(16.18) D(21.13) F(18.85)							

Table 5. Continued.

Horse power of engine (PS)	Side trawler (ton per 1 hour haul)			Stern trawler (ton per 1 hour haul)						
	1965	1966	1967	1966	1967	1968	1969	1970	1971	1972
550	A (2.69) B1(7.84) ¹⁾ B2(3.04)	A(9.44)								
650								C (7.83)		
750	A (4.46) B1(9.55) B2(4.84)	A(10.67)	A(8.78)							
850	A (5.16) B1(10.22) B2(4.65)	A(10.57)	A(10.39)							
1,150				A(14.04)	A(15.79)	A(13.21)	A1(16.36) ¹⁾ A2(18.05)	A(11.25)	A(10.98)	
1,250				B(1.38)	A(13.85)	A(15.20)	A(13.37)	A1(16.91) A2(17.14)	A(10.91)	A(11.12)
1,350					A(15.71)	A(13.75) D(6.33)	A1(16.11) A2(18.09)	A(11.02)	A(10.78)	
1,650							D(9.77)	D (10.06)	D(9.93)	
1,850									F(9.84)	F(7.18)

1) Two voyages were made.

ratio is calculated. In other words, we look first for the relation between horsepower and relative catchability on the basis of the data obtained for the classes which operated together with the standard class. Then, from this formula, the relative catchability of the second standard class is obtained. The relative catchability of each further class is obtained by reference to the former relative catchability. Then the formula of horsepower - relative catchability relation is worked out by using the complete data.

The classes with 375 and 625 horsepower consists of pair trawlers and the class with 275 horsepower with Danish seiners is used as the second standard class. The unit of effort is one net haul for Danish seiners and one-hour haul for the others.

The vessel used as search ship in a fleet is easily identified by the extremely small amount of total effort and catch when compared to other vessels and therefore was excluded from the calculation. As the relative catchability of each class is considered to vary also according to target species of catch, only those specializing in catching pollock from 1965 on were calculated. The number of vessels by fleet and by fishing method, used in this computation is shown in the appended table.

The relative catchability of vessels according to each class of horsepower obtained above was plotted in Figures 6-8. The relationship of relative catchability and horsepower can be expressed by the following formula.

$$Y = a + bX + cX^2 \dots \dots \dots (2) \quad /p. 15/$$

Y is the relative catchability and X is the horsepower (100 horsepower unit) of the fishing vessels. The values of the constants in formula (2) are shown in Table 6 by different fishing method. The curves estimated by using these constants are shown in Figures 6-8.

In pair trawlers, the relative catchability increases with the horsepower. However the rate of increase eventually diminishes gradually (Figure 6). In Danish seiners, the relative catchability increases with the horsepower up to 950. However, the rate of increase is smaller than that of pair trawlers. Beyond 950 horsepower the relative catchability decreases (Figure 7). In side trawlers, the relative catchability increases with the horsepower up to 850, and their rate of increase is the largest (Figure 8). In stern trawlers, the values of samples concentrated around 1,150-1,350 horsepower. Therefore, there is hardly any difference in relative catchability within this range of horsepower. /p. 16/

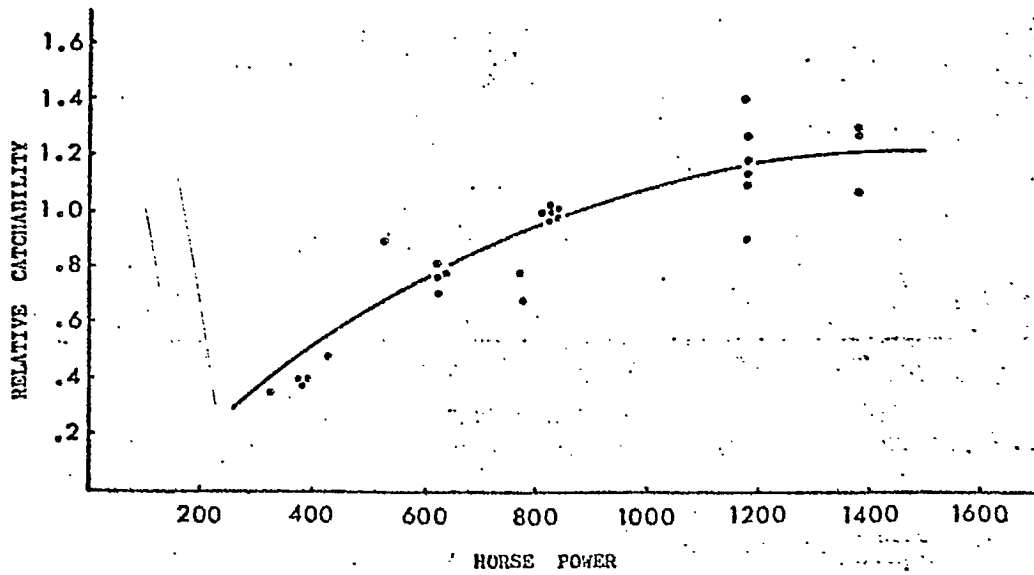


Fig. 6. The relationship between the relative catchability of the vessel and its horse power of engine of the pair trawlers in the mince mothership fleets in the Bering Sea, 1965-1972.

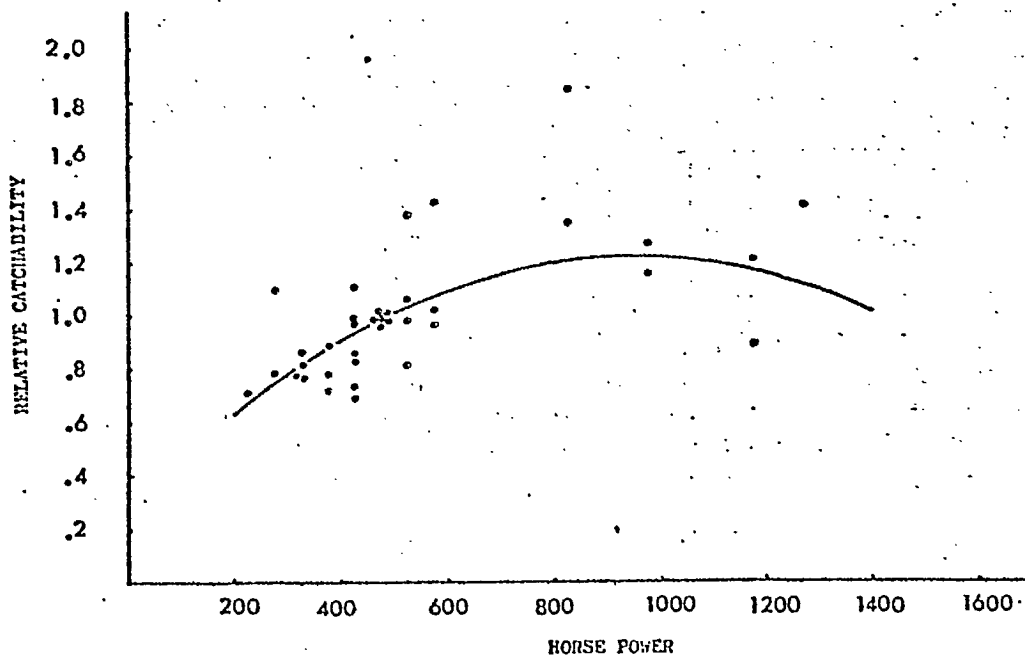


Fig. 7. The relationship between the relative catchability of the vessel and its horse power of engine of the Danish seiners in the mince mothership fleets in the Bering Sea, 1965-1972. Plots are one second of all the data.

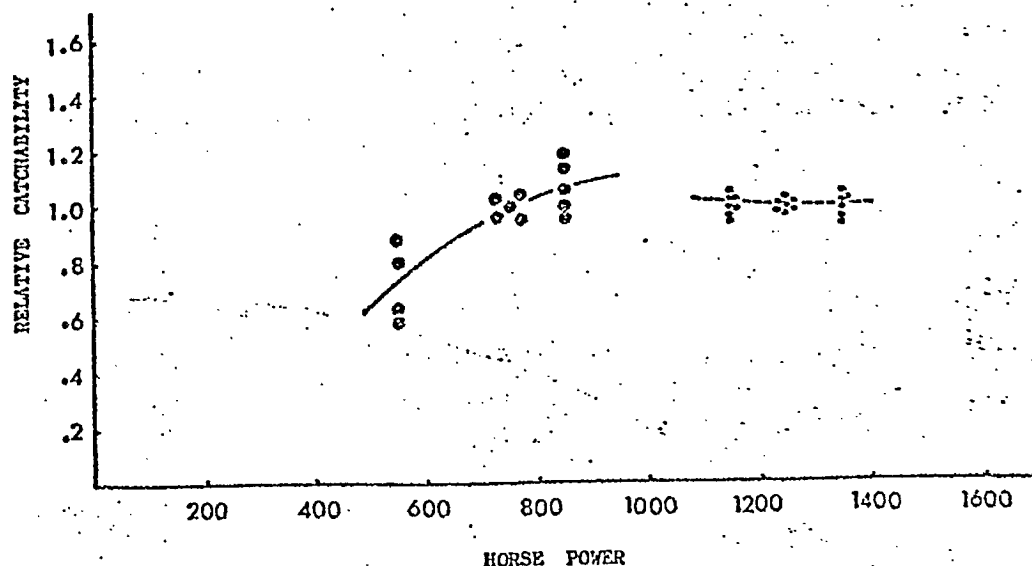


Fig. 8. The relationships between the relative catchabilities of the vessels and its horse powers of engines of the side trawlers and stern trawlers in the mince mothership fleets in the Bering Sea, 1965-1972.

- ⊙ : Side trawler
● : Stern trawler

Table 6. The values of the constants of the formula, $Y=a+bX+cX^2$, expressing the relationship between the horse power of engine and the relative catchabilities of the vessels operated in the mothership pollock fishery in the Bering Sea, 1965-1972. Y is the relative catchability and X is horse power of engine (100 PS).

Gear	Constant	a	b	c
Pair trawler		-0.1592	0.1879	-0.0064
Danish seiner		0.2726	0.1997	-0.0105
Side trawler		-0.8307	0.3954	-0.0202
Stern trawler		2.5153	-0.2406	0.0095

Relative Catchability of Pair Trawlers and Danish Seinners

As was already mentioned, the fishing grounds of both pair trawlers and Danish seinners are on the Continental shelf. So their relative catchability was compared by the same method as above. That is, among the vessels attached to the same mothership the catch per one net haul of Danish seinners with various horsepower engines was

compared with the catch per one-hour haul of pair trawlers with 825 horsepower engines. The result is shown in Figure 9. The following formula was obtained by applying the quadratic equation which was used as shown above.

/p. 17/

$$Y = -0.0347 + 0.1212X - 0.0064X^2 \dots \dots \dots (3)$$

The relative catchability Y is the catch per one net haul of Danish seiners when the catch per one-hour haul of pair trawlers with a 825-horsepower engine is regarded as 1. X is the horsepower (100 horsepower unit) of Danish seiners. The highest value obtained by the relation formula is 0.55 when the horsepower is around 950. Beyond this, the relative catchability of Danish seiners decreases when the horsepower increases. The average of total samples is 0.423.

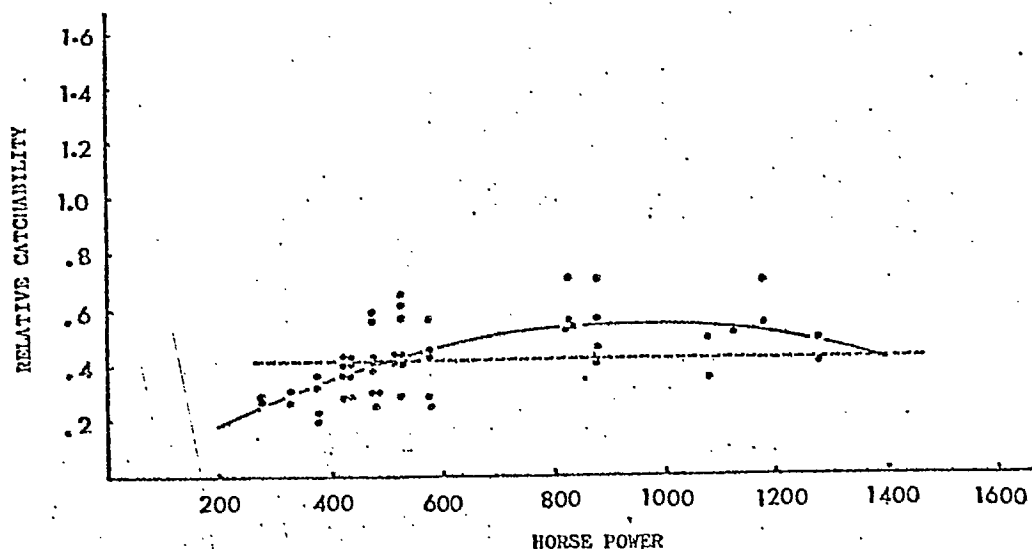


Fig. 9. The relationship between the catchabilities of the pair trawler with 825 PS engine and the ones of the Danish seiners with various horse power engines in the mince mothership fleets in the Bering Sea, 1965-1972.

Annual Change in the Relative Catchability of Operating Fishing Vessels

The average horsepower was obtained from the yearly average tonnage (Table 2) of the fishing vessels operated between 1965-1972, by Formula (1) and Table 3. Then, the annual relative catchability of the vessels operated was obtained by different fishing method, through Formula (2) and Table 6. The result is shown in Table 7. In the case of Danish seiners, the annual average tonnage changes greatly depending on whether or not large types of more than 150 tons were used during that year. Therefore the calculation was made only for those under 150 tons. In the case of side trawlers and stern trawlers, vessels over 500 tons were excluded from the calculation.

/p. 18/

Table 7. The annual average gross-tonnage, horse power of engine, and the relative catchabilities of the vessels in the mothership pollock fishery in the Bering Sea, 1965-1972. The standard stratum of the relative catchability is different at each gear.

Year	Pair trawl ¹⁾				Danish seine				Side trawl				Stern trawl						
	Gross tonnage (100ton)	Horse power (100PS)	(1)		(2)		Gross tonnage (100ton)	Horse power (100PS)	Rela- tive catch- with ability 1968		Gross tonnage (100ton)	Horse power (100PS)	Rela- tive catch- with ability 1968		Gross tonnage (100ton)	Horse power (100PS)	Rela- tive catch- with ability 1968		
			Rela- tive catch- with ability 1968	Com- parison with ability 1968	Horse power (100PS)	Rela- tive catch- with ability 1968			Com- parison with ability 1968	Rela- tive catch- with ability 1968			Com- parison with ability 1968	Rela- tive catch- with ability 1968			Com- parison with ability 1968		
1965	1.063	3.284	0.384	0.665	3.254	0.385	0.654	0.816	3.333	0.822	0.852	3.428	6.943	0.941	0.921	3.000	12.296	1.001	1.001
1966	1.030	3.152	0.369	0.631	3.117	0.364	0.619	0.800	3.201	0.804	0.833	3.359	6.748	0.918	0.899	3.167	12.614	1.000	1.000
1967	1.179	3.795	0.462	0.790	3.782	0.460	0.782	0.881	3.930	0.895	0.927	3.350	6.717	0.914	0.895	3.040	12.372	1.006	1.006
1968	1.354	4.721	0.595	1.000	4.744	0.588	1.000	0.940	4.565	0.965	1.000	3.700	7.758	1.021	1.000	3.061	12.420	1.000	1.000
1969	1.322	4.536	0.561	0.959	4.551	0.563	0.958	0.983	5.091	1.017	1.054	3.450	7.000	0.947	0.928	3.078	12.446	1.000	1.000
1970	1.607	6.473	0.789	1.349	6.595	0.801	1.361	0.995	5.248	1.031	1.068	3.400	6.857	0.931	0.912	3.142	12.569	1.000	1.000
1971	1.766	7.893	0.925	1.581	8.092	0.942	1.602	1.008	5.424	1.047	1.085	--	--	--	--	3.109	12.504	1.000	1.000
1972	1.833	8.581	0.982	1.679	8.826	1.001	1.701	1.033	5.779	1.076	1.115	--	--	--	--	3.129	12.544	1.000	1.000

1) See Fig. 3.

There is a tendency for pair trawlers to become larger every year. If the relative catchability in 1968, the year when pollock fishery is considered to have developed on a full scale, is regarded as 1, the relative catchability of 1972 is 1.7. Most Danish seiners are below 150 tons. However, within that range there is a tendency for them to become larger. If the relative catchability in 1968 is considered 1, that in 1972 is 1.1. There is a trend towards side trawlers being replaced by stern trawlers, so that the number of operating side trawlers decreases together with the relative catchability. Many stern trawlers are North Sea Transfer vessels ("hokuyo tenkansen") as was already mentioned and they have already grown close to their maximum tonnage. Therefore their annual relative catchability showed hardly any difference.

/p. 17/

Comments

From the operating conditions of mothership fishing, it was considered that vessels attached to a mothership, except for the research vessel, are competitive with each other within a considerably small fishing area; their target is limited only to pollock, and neither do they change the nets to catch other species nor do variations in size determine other target species. However, in fact, more than 10 o/o of the total catch during 1965-1966 consisted other species. Then it must be assumed that maybe the target species do vary according to the size of the vessel during a certain period. However, this still needs to be verified by studying in detail the daily fishing records.

/p. 19/

It is considered that the density of the pollock resource changed during the period of the investigation. However, it is not clear whether or not this change caused a difference in the catchability of vessels according to various horsepower. In this paper, it is assumed that there was none.

Lenarz et al. reported (1973) on ocean bed fishing in the north west Atlantic where many kinds of fishing effort (also nationality wise) have been invested. According to their report, the relative catchability in relation to fishing effort is, first of all, greatly influenced by the tonnage and the nationality of the vessels, and secondly by the target species. In this paper, the calculation employed by Lenarz et al. is not used because the results obtained did not differ from the forecasts made at the beginning.

The number of vessels operated varies according to the tonnage class. Therefore the accuracy of the average value also varies according to each class. Due to this kind of error, results, of course, are expected to be different depending on which class is chosen as standard, especially as second standard. Therefore, the class with the largest number of vessels ought to be selected in order to minimize this kind of error.

In the case of trawlers, the increase in tonnage brought about an increase in engine horsepower. Together with the increase of net size made possible by an increase in hauling power, and the increase in the hauling-net speed, it raised the catchability. Therefore the comparison of yearly catchability also should be based on engine horsepower. However, it was, generally difficult to know the shaft

horsepower of each vessel. Therefore, the yearly change in relative catchability had to be calculated from the yearly change in the vessel tonnages for which pertinent data were most readily available. However, this procedure raised two problems. The first problem is what to do with the vessel which were abandoned during the process of trail and error at the time of investigating the relationship between tonnage and shaft horsepower. In this paper, the groups of Danish seiners and side trawlers whose horsepower per ton is small are excluded from the calculation. In the case of pair trawlers, two calculations were made, one excluding the low horsepower groups and other including them, and the results were compared to observe the extent of difference. The second problem is the calculation of the average tonnage of fishing vessels operated each year. Large-model vessels, over 150 tons in the case of Danish seiners and over 500 tons in the case of side trawlers and stern trawlers (these are in the group in which the horsepower per ton is small) were excluded from the calculation. Further examination is necessary concerning how to deal with this small number of vessels.

Table 8. The catch of pollock by the mothership pollock fishery in the Bering Sea, by gear, 1965-1972. (100 metric ton).

Gear \ Year	1965	1966	1967	1968	1969	1970	1971	1972
Total	2,255	2,555	5,353	6,398	6,713	10,073	10,744	11,443
Pair trawl	443	609	1,375	1,676	1,485	3,664	4,851	6,268
Danish seine	1,764	1,295	2,540	3,263	3,523	4,456	3,624	3,130
Side trawl	47	651	506	112	80	44	—	—
Stern trawl	—	1	932	1,346	1,625	1,909	2,269	2,046

In mothership pollock fishery, 4 fishing methods are used; they are pair trawling, Danish seine, side trawling and stern trawling. The catch by each method changes each year (Table 8). This tendency to change corresponds to the tendency observed in the yearly change in relative catchability. That is, the catch by pair trawlers increases but the catch by side trawlers decreases. The yearly change in relative catchability also varies according to the fishing method. Fishing grounds also differ depending on the method. Therefore, it is difficult to evaluate accurately the all-round yearly relative catchability for all these presently used 4 fishing methods.

Northern trawl fishing is used as well as mothership fishing to catch pollock in the eastern Bering Sea (Table 1). As to the former, further study is necessary in order to determine the yearly changes in relative catchability.

As to more fundamental problems, there is a need for research in the method of expressing fishing effort which corresponds to the fishing system (how to determine the unit).

Summary

- 1) The mothership pollock fishing in the eastern Bering Sea began around 1965 when the target species changed from yellowfin sole to pollock (Figure 1, Table 1).
- 2) Fishing vessels used in the mothership fishery are pair trawlers, Danish seiners, side trawlers and stern trawlers. The former two are operated on the continental shelf and the latter two on the slope of the continental shelf.

- 3) The fishing vessels belonging to the mothership, except for one or two vessels searching schools of fish, operate within a radius of approximately 20 miles and within this area their operations are freely competitive with each other.
- 4) In general, the fishing grounds are on the continental shelf and its slope north of the Unimak Pass from November to May; from June to October they gradually move north from the Pribilof Islands to Cape Navarin along the edge of the continental shelf (Figure 2).
- 5) The annual change in the tonnage of the vessels operated was examined. The tonnage of the pair trawlers is 90-120 tons from 1965 to 1966 but mostly 170-210 tons from 1971 to 1972. The tonnage of most Danish seiners is around 50-140 tons. They grow larger in size every year, and in 1967 there were large size vessels of 200 or 300 tons in operation. Later, however, large size vessels of more than 150 tons decreased in number. The side trawlers tend to be replaced by stern trawlers. A number of side trawlers were used in 1965-1966, but the number decreased later. The stern trawlers increased in number since 1967. Many of them are North Sea Transfer vessels, "hokuyo tenkansen", and their size has already reached near the maximum limit in tonnage. Therefore increase in size of the fishing vessels was not taken into account.
- 6) When the tonnage is expressed as X (100 ton unit) and the engine horsepower as Y (100 horsepower unit), the relation between the two is as follows:

$$Y = ab^X \dots \dots \dots (1)$$

The values of the constants are shown in Table 3.

7) The size of the nets used was examined in each tonnage class of the vessels. It was found that the greater the tonnage the larger the net used (Table 4).

8) Judging from the operating conditions of mothership fishing, it was considered that the relative catchability of the fishing vessels belonging to the same mothership can be compared for each fishing vessel size by comparing their catch per effort. Also on the basis of consideration that the relative catchability of a pair trawler and a Danish seiner operated on the same continental shelf can be compared in the same manner, the following comparison was made.

9) The engine horsepower which determines the hauling power of nets is the factor that determines directly the difference in catchability according to the size of the vessels. Therefore, the vessels were classified into groups according to the shaft horsepower of their engines. For each fishing method, the group which had the longest operating records and the largest number of vessels was chosen as standard class. Then the catch per average effort of each class was compared.

10) As a result, the relation between the shaft horsepower X (100 horsepower unit) and the relative catchability Y of the vessels is expressed by the following formula. The constants were calculated according to each fishing method (Table 6), and their curves are shown in Figures 6-8.

$$Y = a + bX + cX^2 \dots \dots \dots (2)$$

11) In order to compare the relative catchability of pair trawlers and Danish seiners, considering the catch per one-hour haul by pair

trawlers in the standard class as 1, the relative catch per one net haul of Danish seiners was calculated for each horsepower class. The relation between the horsepower (100 horsepower unit) of Danish seiners and their relative catchability Y is as follows.

$$Y = -0.0347 + 0.1212X - 0.0064X^2 \dots \dots \dots (3)$$

When the total average value was calculated, it was found that one net haul of Danish seiners corresponds to 0.423-hour haul of pair trawlers with an 825 horsepower engine.

12) From the annual average tonnage of the vessels operated from 1965 to 1972, the average engine horsepower was calculated by Formula (1) and Table 3, and the yearly relative catchability was calculated by Formula (2) and Table 6, according to each fishing method. If the relative catchability of 1968, when the transition to pollock fishery is considered to have ended, is regarded as 1, the relative catchability of pair trawlers and Danish seiners in 1972 increases 1.7 times and 1.1 times respectively. Whereas, the relative catchability of side trawlers decreases and in stern trawlers there is hardly any difference from year to year.

13) Catch volume according to each fishing method varies annually. The relative importance of each fishing method in the total catch changes also (Table 8). Since the fishing grounds of otter trawlers differ from the fishing grounds exploited by other methods, it is difficult to evaluate accurately the yearly change in the relative catchability of all the vessels in a mothership fishery concern employing all these fishing methods.

14) It was impossible to examine the yearly change in the relative

catchability of the vessels operated by the northern trawl fisheries to catch pollock in the eastern Bering Sea.

15) The unit of fishing effort for trawl fishing is expressed as "one net haul" or "one-hour haul". However, it does not indicate the size of net or the hauling power or speed of vessel. Therefore, there is still a need for basic research to define the unit of fishing effort.

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Appendant table The names of the mince fleets, number of vessels and catches, by gear and gross-tonnage, used for the calculation of the relationships between the gross-tonnage, horse power of engine and the relative catchabilities, 1965-1972, in the Bering Sea¹⁾.

Year		1965											
Fleet		A			B(1) ²⁾			B(2) ²⁾			C ³⁾		
Gear	Gross-tonnage	Number of vessels	Total catch (100 ton)	Catch of pollock (100 ton)	Number of vessels	Total catch (100 ton)	Catch of pollock (100 ton)	Number of vessels	Total catch (100 ton)	Catch of pollock (100 ton)	Number of vessels	Total catch (100 ton)	Catch of pollock (100 ton)
Pair trawl	110	—	—	—	—	—	—	—	—	—	4	148	147
	120	—	—	—	—	—	—	—	—	—	2	65	65
Danish seine	60	—	—	—	—	—	—	—	—	—	2	56	78
	70	4	46	38	—	—	—	4	183	164	7	325	294
	80	11	146	115	—	—	—	4	194	170	9	377	344
	90	2	9	7	—	—	—	1	59	53	1	52	47
Side trawl	120	1	12	9	—	—	—	—	—	—	—	—	—
	130	2	15	12	—	—	—	—	—	—	—	—	—
	140	1	17	15	—	—	—	—	—	—	—	—	—
	300	—	—	—	—	—	—	—	—	—	1	24	22
Side trawl	270	—	—	—	1	30	23	—	—	—	—	—	—
	290	1	5	4	1	43	34	1	1	1	—	—	—
	370	5	60	44	4	249	196	5	12	11	—	—	—

Year		1966								
Fleet		A			B			C		
Gear	Gross-tonnage	Number of vessels	Total catch (100 ton)	Catch of pollock (100 ton)	Number of vessels	Total catch (100 ton)	Catch of pollock (100 ton)	Number of vessels	Total catch (100 ton)	Catch of pollock (100 ton)
Pair trawl	90	4	116	108	—	—	—	—	—	—
	110	—	—	—	—	—	—	6	295	179
	120	—	—	—	—	—	—	2	90	54
Danish seine	70	—	—	—	1	19	15	—	—	—
	80	3	36	30	7	157	128	14	570	512
	90	—	—	—	4	117	97	—	—	—
	100	—	—	—	2	48	42	3	95	89
	200	—	—	—	1	18	17	—	—	—
Side trawl	300	—	—	—	—	—	—	1	31	31
	270	1	62	59	—	—	—	—	—	—
	290	1	41	43	—	—	—	—	—	—
Stern trawl	370	5	323	310	—	—	—	—	—	—
	310	—	—	—	3	22	1	1	27	8
	360	—	—	—	—	—	—	1	25	11

Year		1967											
Fleet		A			C			D ²⁾			E ²⁾		
Gear	Gross-tonnage	Number of vessels	Total catch (100 ton)	Catch of pollock (100 ton)	Number of vessels	Total catch (100 ton)	Catch of pollock (100 ton)	Number of vessels	Total catch (100 ton)	Catch of pollock (100 ton)	Number of vessels	Total catch (100 ton)	Catch of pollock (100 ton)
Pair trawl	110	—	—	—	8	560	514	2	152	114	—	—	—
	120	—	—	—	2	135	123	2	146	110	—	—	—
	170	—	—	—	—	—	—	4	350	266	—	—	—
Danish seine	70	—	—	—	—	—	—	—	—	—	1	43	33
	80	—	—	—	5	320	250	2	127	98	9	361	239
	90	—	—	—	3	254	200	—	—	—	8	328	253
	100	—	—	—	5	325	248	—	—	—	7	344	270
	140	—	—	—	—	—	—	—	—	—	1	38	28
	200	—	—	—	—	—	—	—	—	—	1	47	38
	270	1	6	4	—	—	—	—	—	—	1	7	4
	280	1	15	5	—	—	—	—	—	—	1	38	31
290	—	—	—	—	—	—	—	—	—	1	2	2	
300	1	22	14	1	44	35	—	—	—	6	51	42	
Side trawl	370	5	502	458	—	—	—	—	—	—	—	—	—
	540	—	—	—	—	—	—	1	24	20	—	—	—
Stern trawl	300	7	935	879	—	—	—	—	—	—	4	25	25
	310	—	—	—	—	—	—	1	31	23	7	64	63

Year		1968					
Fleet		A			E		
Gear	Gross-tonnage	Number of vessels	Total catch (100 ton)	Catch of pollock (100 ton)	Number of vessels	Total catch (100 ton)	Catch of pollock (100 ton)
Danish seine	80	—	—	—	5	299	274
	90	—	—	—	5	313	283
	100	—	—	—	12	773	704
Stern trawl	300	7	620	608	—	—	—
	310	1	1	1	—	—	—

Year		1969								
Fleet		A			D			E		
Gear	Gross-tonnage	Number of vessels	Total catch (100 ton)	Catch of pollock (100 ton)	Number of vessels	Total catch (100 ton)	Catch of pollock (100 ton)	Number of vessels	Total catch (100 ton)	Catch of pollock (100 ton)
Pair trawl	110	—	—	—	2	131	106	—	—	—
	170	—	—	—	2	198	161	—	—	—
	180	—	—	—	2	207	165	—	—	—
	190	—	—	—	2	266	214	—	—	—
Danish seine	80	—	—	—	1	101	87	4	253	230
	90	—	—	—	1	93	79	3	201	188
	100	—	—	—	4	391	331	16	935	510
	120	—	—	—	1	82	74	—	—	—
Stern trawl	300	7	1,221	1,219	—	—	—	—	—	—
	310	1	9	9	1	80	70	—	—	—
	330	—	—	—	1	195	166	—	—	—

Year		1970														
Fleet		A(1) ²¹			A(2) ²¹			C			D			E		
Gear	Gross-tonnage	Number of vessels	Total catch (100 ton)	Catch of pollock (100 ton)	Number of vessels	Total catch (100 ton)	Catch of pollock (100 ton)	Number of vessels	Total catch (100 ton)	Catch of pollock (100 ton)	Number of vessels	Total catch (100 ton)	Catch of pollock (100 ton)	Number of vessels	Total catch (100 ton)	Catch of pollock (100 ton)
Pair trawl	110	—	—	—	—	—	—	8	232	211	—	—	—	—	—	—
	170	—	—	—	—	—	—	—	—	—	4	422	370	2	133	133
	180	—	—	—	—	—	—	2	274	232	—	—	—	4	317	317
Danish seine	190	—	—	—	—	—	—	2	330	278	4	538	470	—	—	—
	80	—	—	—	—	—	—	1	93	87	—	—	—	2	150	130
	90	—	—	—	—	—	—	—	—	—	1	84	72	1	77	72
Stern trawl	100	—	—	—	—	—	—	9	711	638	7	704	595	11	1,001	535
	120	—	—	—	—	—	—	1	127	114	1	108	99	—	—	—
Stern trawl	300	7	1,250	1,250	7	1,343	1,343	—	—	—	—	—	—	—	—	—
	310	1	131	131	—	—	—	1	122	107	—	—	—	—	—	—
	350	—	—	—	1	35	35	—	—	—	1	220	217	—	—	—

Year		1971											
Fleet		A			D			E			F		
Gear	Gross-tonnage	Number of vessels	Total catch (100 ton)	Catch of pollock (100 ton)	Number of vessels	Total catch (100 ton)	Catch of pollock (100 ton)	Number of vessels	Total catch (100 ton)	Catch of pollock (100 ton)	Number of vessels	Total catch (100 ton)	Catch of pollock (100 ton)
Pair trawl	170	—	—	—	—	—	—	2	207	207	—	—	—
	180	—	—	—	—	—	—	10	1,060	1,060	3	272	243
	190	—	—	—	8	964	867	2	93	93	8	915	823
Danish seine	80	—	—	—	—	—	—	1	66	65	—	—	—
	90	—	—	—	1	94	87	1	59	58	2	163	153
	100	—	—	—	8	699	649	8	462	456	7	566	515
Stern trawl	120	—	—	—	1	98	91	—	—	—	3	286	261
	300	7	1,050	1,050	—	—	—	—	—	—	—	—	—
	310	1	121	120	—	—	—	—	—	—	—	—	—
Stern trawl	350	—	—	—	1	194	180	—	—	—	1	187	167

Year		1972														
Fleet		A			C			D			E			F		
Gear	Gross-tonnage	Number of vessels	Total catch (100 ton)	Catch of pollock (100 ton)	Number of vessels	Total catch (100 ton)	Catch of pollock (100 ton)	Number of vessels	Total catch (100 ton)	Catch of pollock (100 ton)	Number of vessels	Total catch (100 ton)	Catch of pollock (100 ton)	Number of vessels	Total catch (100 ton)	Catch of pollock (100 ton)
Pair trawl	170	--	--	--	--	--	--	--	--	--	2	215	215	--	--	--
	180	--	--	--	--	--	--	2	192	177	10	1,092	1,092	--	--	--
	190	--	--	--	4	878	823	4	569	523	2	235	235	10	1,341	1,253
	200	--	--	--	--	--	--	2	311	290	2	230	230	--	--	--
	210	--	--	--	2	190	180	2	168	153	--	--	--	2	198	183
Danish seine	80	--	--	--	1	80	74	--	--	--	--	--	--	--	--	--
	90	--	--	--	--	--	--	1	73	69	--	--	--	1	85	78
	100	--	--	--	5	389	364	6	479	451	5	343	243	6	492	463
	120	--	--	--	3	226	213	2	217	202	--	--	--	5	454	434
Stern trawl	300	8	1,132	1,132	--	--	--	--	--	--	--	--	--	--	--	--
	310	1	8	8	1	75	73	--	--	--	--	--	--	--	--	--
	350	--	--	--	--	--	--	1	133	120	--	--	--	1	123	118

- 1) These figures came from the fishing companies. There are some discrepancies between the catch statistics of the Far Seas Fisheries Research Laboratory.
- 2) Two voyages were made, when a voyage covered two calendar year it was expressed at the departure time.
- 3) Used for the calculation of relationship between gross-tonnage and horse power of engine only, because the fishing efforts were not available.