Studies of the Whaling Grounds in the Northern Sea-Region of the Pacific Ocean in Relation to the Meteorological and Oceanographic Conditions. (Part I)

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Introduction

Hitherto there were very few researches on the environmental conditions of whale shoaling and whaling. M. Uda already reported on the concentration of whales in the core of cyclonic eddies along the frontal boundary of different water masses in the adjacent seas of Japan[1]. In the present paper the relation between the northern whaling grounds in 1954 and weather conditions (cyclone, sea-fog etc.) together with sea-conditions was studied.

I. Whaling Conditions in Relation to the Passage of Cyclone.

1) Cyclone hitted to the whaling grounds in the Northern Sea Region of Pacific Ocean.

The cyclones in question may be divided into two types i.e. cyclones started from Siberia and those appeared in the neighbouring waters of Japan.

First in the beginning period of whaling season, cyclone occurs frequently in the region adjacent to the Maritime Province of Siberia. In the middle season of whaling, the path moves to north a little. The former enters in the Bering Sea after passing through Saghalien and Kurile Islands, and the latter proceeds into the Bering Sea through the Kamchatka Peninsula, after crossing the Okhotsk Sea. All of these cases do not accompany with their storms in general. Especially the cyclones appeared in the vicinity of Kamchatka Peninsula in the period from June to July, are rarely accompanied by storms.

2) Cyclone originated in the adjacent waters of Japan.

Those cyclones in the temperate latitudes developing during their

procession to NE direction arrive in Bering Sea and are accompanied by storms.

3) Relation between the whaling conditions and the cyclone.

The amount of whaling catch was analysed by the statistical method already taken in case of yellow-tail[2] by M. Uda.

Taking the day of nearest approach by the cyclone center to the mother boat of a whaling set as zero day, and denoting those 2 days and 1 day before the zero day, 2 days and 1 day, after the zero day as -2, -1, $+1$ and $+2$ respectively and then the distribution curve of the amount of whaling catch for each 5 days was plotted in fig. 1.

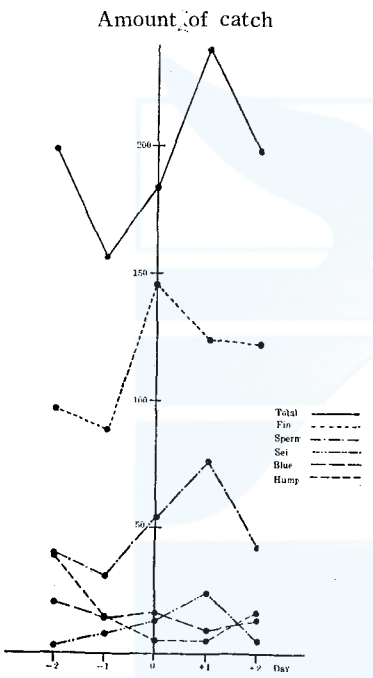

Fig. 1. The amount of whale catch accumulated for each species on -2, -1, 0, $+1$ and $+2$ respectively.

The analysis was made on the data during the 20 days in 1954, which is too few to get concrete results and only capable to infer trend of the matter.

First as a general consideration, for each species of whales the amount of catch was summed up separately on the -2, -1, 0, $+1$ and $+2$ day. Then as we see in fig. 1 and table 1 on the $+1$ day the catch shows its maximum and on the -1 day its minimum showing almost similar value on the -2 and $+2$ day. On the zero day the amount of whale catch is more abundant than that of the -1 day and lower than those of the $+2$ and -2 day. Accordingly on the days adjacent to the $+1$ day after the cyclone passage, it shows favourable whaling conditions.

Such considerations were paid for each species of whales. Fin whale and sperm whale having abundant catch show the tendency similar to the total catch, i.e. on the -1 day, it shows the minimum catch and on the $+1$ day the maximum.

Although for humpback whale and blue whale, the relations are obscure. Owing their poor catches, for humpback whale the curve seems to show the maximum on about the -2 day and the minimum on the $+1$ day and similar curve for the catch of blue whale, however for sei whale the case almost reverse to those of blue whale and humpback whale, i.e. the curve showing the minimum on the -2 day and the maximum on the $+1$ day.

4) On the relation between the shoaling amount of whales and the cyclone.

The shoaling amount of whales should be conjectured by their catches together with the oceanographic and meteorological conditions. Here we can put the following relational formula on the amount of whale catch.

$$F=K.\ V.\ S.\ O. \qquad \ldots(1)$$

where
F: amount of the whale catch.
V: the rate of discovery by ordinary look-out.
S: shoaling amount of whales.
O: rate of whaling operation.
K: proportional constant, depending on the characteristics of planktonic, topographic and other elements of the whaling ground.

Since the amount of the whale catch is varied by the approach of the cyclone, the writers studied this relation statistically during the whaling season in 1954.

Hence the shoaling amount of whales is the fundamentally important factor to determine the amount of catch.

The rate of whaling operation and rate of discovery can be known easily, and the amount of catch is known too. Thereby, the writers intended to carry quantitative analysis on the shoaling condition of whale in relation to cyclone passage.

(*a*) *The shoaling condition of whale: S*

It is evident that due to the influence of the cyclone, the sea condition become unfavourable, whereas (S) increase with the approach of the cyclone, and is proportional to (F).

(*b*) *The rate of discovery by ordinary look-out: V*

When the cyclone approaches to the whaling ground, the southerly wind blows and arouses the dense sea-fog, so that the rate of discovery decreases. Since naturally the amount of catch (F) may be proportional to (V), it may be lowered as the consequence of the (F)-decrease in spite of the shoaling amount of whales (S) increases.

(*c*) *The rate of whaling operation: O*

The rate of operation including the meaning of the rate of gun hits and it may be the main factors of the rate of whaling. Here, we may assume the ability of gunners as constant. The rate of gun hits is inversely proportional to the sea condition such as wind-wave or swell. While the rate of whaling operation is also inversely proportional to the sea condition.

Since this can apply not only to the case of whaling, but also to the cases of other fisheries, so the fishing operation in general are influenced negatively by the sea condition due to the cyclone passage.

In the above mentioned formulation, however, $F=K.S.V.O.$ can not represent well the shoaling condition of whales as affected one by the sea condition, but in the first approximation this equation was adopted and tentatively studied. It is obvious that the rate of gun hits is the function of the sea condition. Thus (F) is considered to be inversely proportional to the rate of whaling operation (O) (accordingly rate of whaling). Consequently, we can estimate the shoaling amount of whales (S) by the computed value of F/KVO. The rate of operation (O) is determined by sea condition (W), hence, the (O) is inversely proportional to (W), i.e. $O \propto \frac{1}{W}$.

$$\therefore \quad F=K'.V.\frac{1}{W}S. \qquad \ldots(2)$$

$$\text{or} \quad S=\frac{FW}{K'V} \qquad \ldots(2)'$$

The curve of (S) estimated by (2)′, named as "The Whale Shoaling Curve" is shown in fig. 2, using the average of sea conditions, the rate of discovery and amount of catch are obtained for the days of the cyclone in table 1.

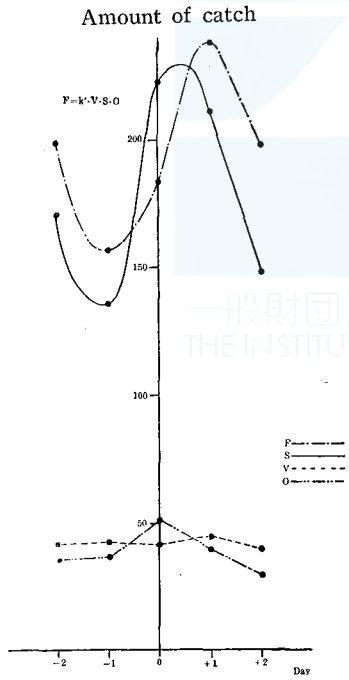

Fig. 2. The whale shoaling curve.

Accordingly,

$$\left.\begin{aligned} 199&=K'\times 4.2\times S_{-2}/3.6\\ 157&=K'\times 4.3\times S_{-1}/3.7\\ 184&=K'\times 4.2\times S_{0}/5.1\\ 238&=K'\times 4.5\times S_{+1}/4.0\\ 198&=K'\times 4.0\times S_{+2}/3.0 \end{aligned}\right\} \begin{aligned} &S_{-2}:S_{-1}:S_{0}:S_{+1}:S_{+2}\\ &=170.6:135.1:\\ &\quad 223.4:211.6:148.5 \end{aligned}$$

Table 1. The value of W. V. and F. in before and after days of the cyclone passage.

Day	−2	−1	0	+1	+2
(W)	3.6	3.7	5.1	4.0	3.0
(V)	4.2	4.3	4.2	4.5	4.0
(F)	199	157	184	238	198

Glancing in fig. 2, We can see at once that the shoaling amount of whales decreases on the days of about −1 and +2, and shows the maximum value on the day of about

+1 and the minimum on the −1 day. Perhaps it occurs because before the cyclone approach, the rate of discovery became to fall down to low level and also the sea became worse. We can suppose, however, that the shoaling of whales does not decrease, by the approach of cyclone. The amount of the whaling catch before and after the cyclone passage, summed up for the species separately.

The total amount of catch (−2, −1, +1 and +2 day) is 540 individuals of whales on the before days, 620 of whales on the after days (the amount of catch on the zero day involved in the both periods). The total heads in the after days are about 7% more than that in the before days.

As shown in fig. 2, on the before days, the curve of the rate of discovery falls with the rise of curve of the sea condition, bad condition to the whaling operation. It may be reasonable that we can not expect better catch on the before days than that on the after days of the cyclone passage. Similarly the catch for each species of whale is shown separately for the −2, −1, 0, +1 and +2 day in table 1, table 2 and fig. 3.

Table 2. The amount of whale catch accumulated for each species on −2, −1, 0, +1 and +2 day respectively.

	Around the nearest day (0 day) of cyclone				
Day / Sp. whal.	−2	−1	0	+1	+2
Humpback	39	15	5	5	16
Sei	3	8	13	24	5
Blue	20	14	16	9	13
Sperm	40	31	54	76	42
Fin	97	89	96	124	122
Total No. of indiv.	199	157	184	238	198

	The catch of 0 day added to both		its percentage	
Sp. whale.	Before days	After days	%	%
Humpback	59	26	69.4	30.6
Sei	24	42	36.4	63.6
Blue	50	38	56.8	43.2
Sperm	125	172	42.1	57.9
Fin	282	342	45.2	54.8
Total No. of indiv.	540	620	46.5	53.4

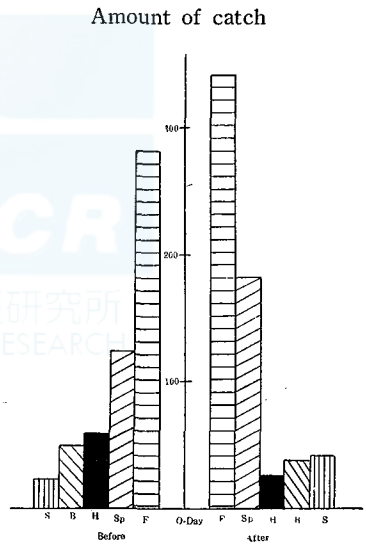

Fig. 3. The amount of whale catch accumulated for each species on before and after days of the cyclone passage.

(i) Fin whale (*Balaenoptera physalus*)

The abundance of the catch on the before and after days of the cyclone passage is 282 and 342 respectively.

The percentage for total catch before and after days of the cyclone passage is 45.2% and 54.8% respectively. In this case the one in the after days are 9.6% more than that in the before days.

(ii) Humpback whale (*Megaptera nodosa*)

The abundance of the catch on the before and after days is 59 and 26 respectively, (i.e. 69.4% and 30.6%). Therefore in the former days it is 38.8% more than that in the latter days, which is seemingly opposite phenomenon to the other species, but the data too few to certify the conclusion.

(iii) Sei whale (*Balaenoptera borealis*)

On the before and the after days of the cyclone passage, the amount of the accumulated catch and its percentage are 24, 42 and 36.4%, 63.6% respectively. In the after days, however, it shows some what good catch, but also in this case, data too few to conclude it.

(iv) Blue whale (*Balaenoptera musculus*)

During the before and the after days of the cyclone passage, the heads of the whale catch are 50 and 38, and its percentages are 56.8% and 43.2% respectively. On the before days, it is 13.6% more than that in the after days.

(v) Sperm whale (*Physeter catodon*)

The abundance of the catch on the before and after days of the cyclone passage is 125 and 172 (i.e. 42.1% and 57.9%) respectively. On the after days, it is 15.8% more than that on the before day.

II. Whaling Conditions in Relation to Weather Elements especially to Sea Fog, and to the Distribution of Dichothermal Water.

(1) Whaling Grounds in the North-Eastern Sea Region of Japan in Relation to Sea Fog in Summer of 1953.

Basing on the data obtained by the whaling catcher boats, one of the authors (M. Uda) plotted the charts of whaling grounds for each decade during the period from the beginning of July to the end of August in 1953 in which the isotherms, the distribution of the rate of fog occurrence (% of fog observed stations among the whole stations in the 1° rectangle of latitude and longitude) and the localities of whale caught included. (See Fig. 4 a, b, c, d, e and f).

We can find at once the relative abundance of whales in the dense fog zones corresponding to the boundaries of cold and warm water masses and to the southward extending cold current areas. The limit of the sea-fog zone lies very near to the Oyasio Front (water tempera-

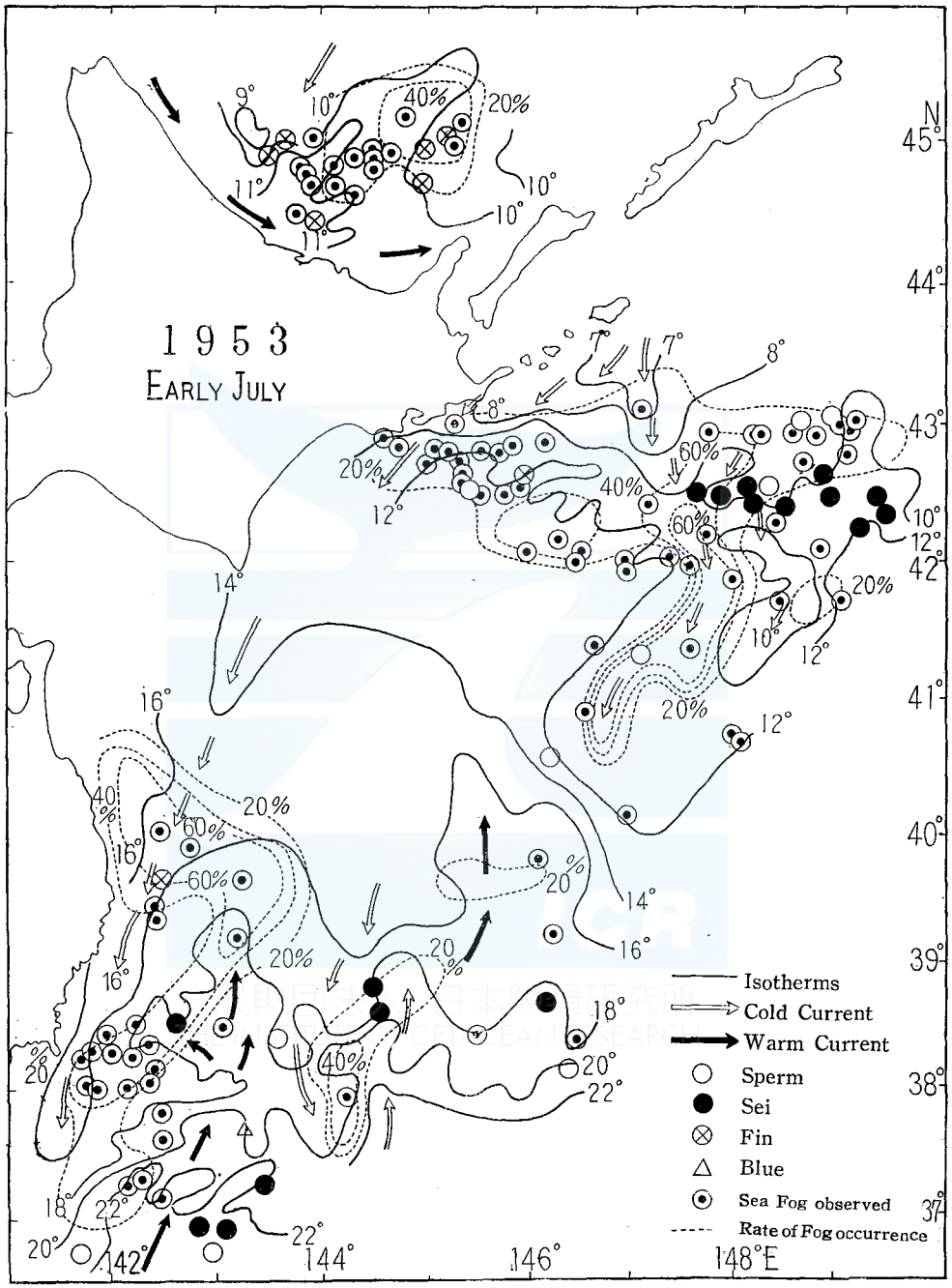

Fig. 4. (a) The distribution of whaling grounds in the North-Eastern Sea Region, water temperature, cold-warm water masses and sea-fog.

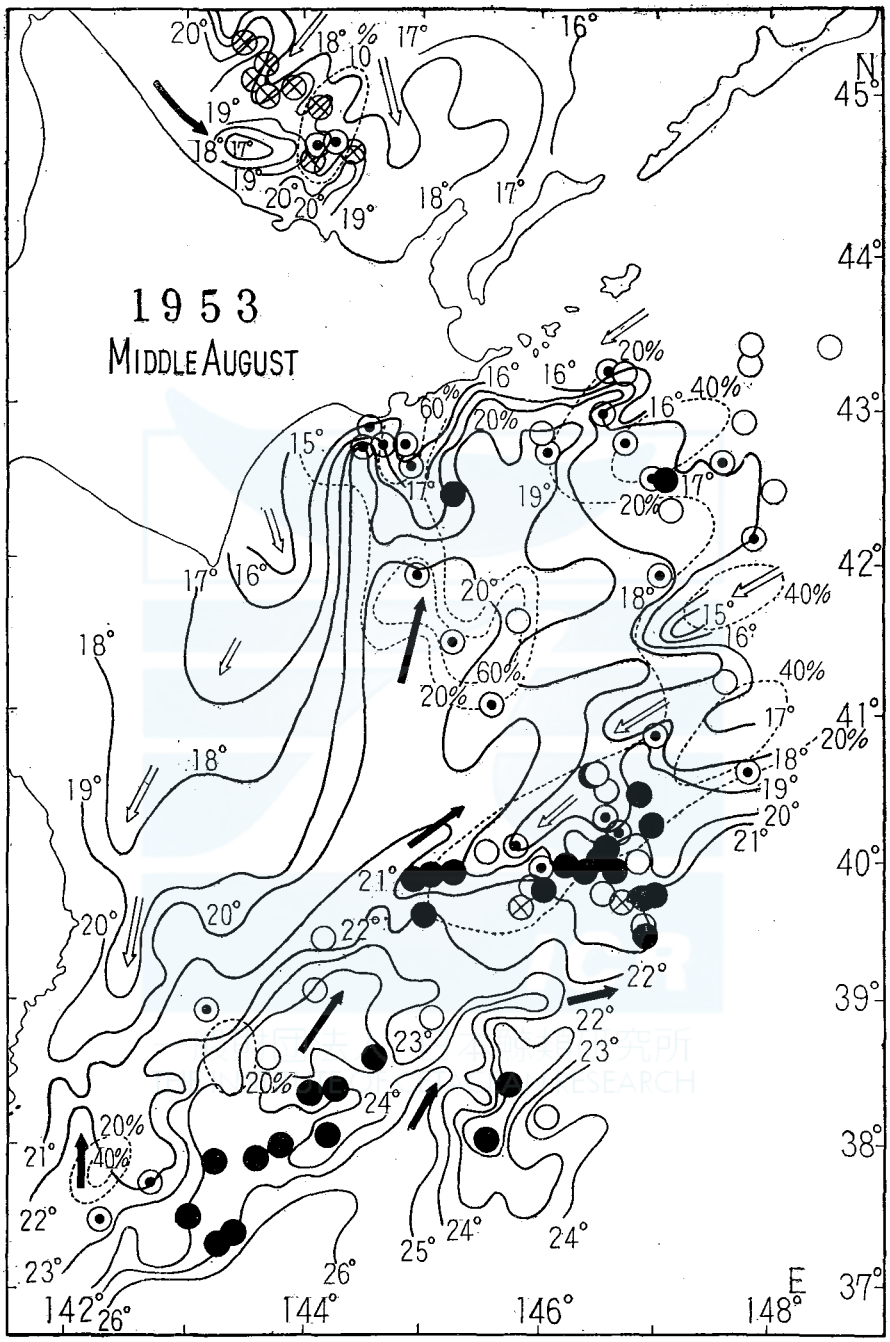

Fig. 4. (b) The distribution of whaling grounds in the North-Eastern Sea Region, water temperature, cold-warm water masses and sea-fog.
(Notice) Notations used in the map are the same as in Fig. 4a.

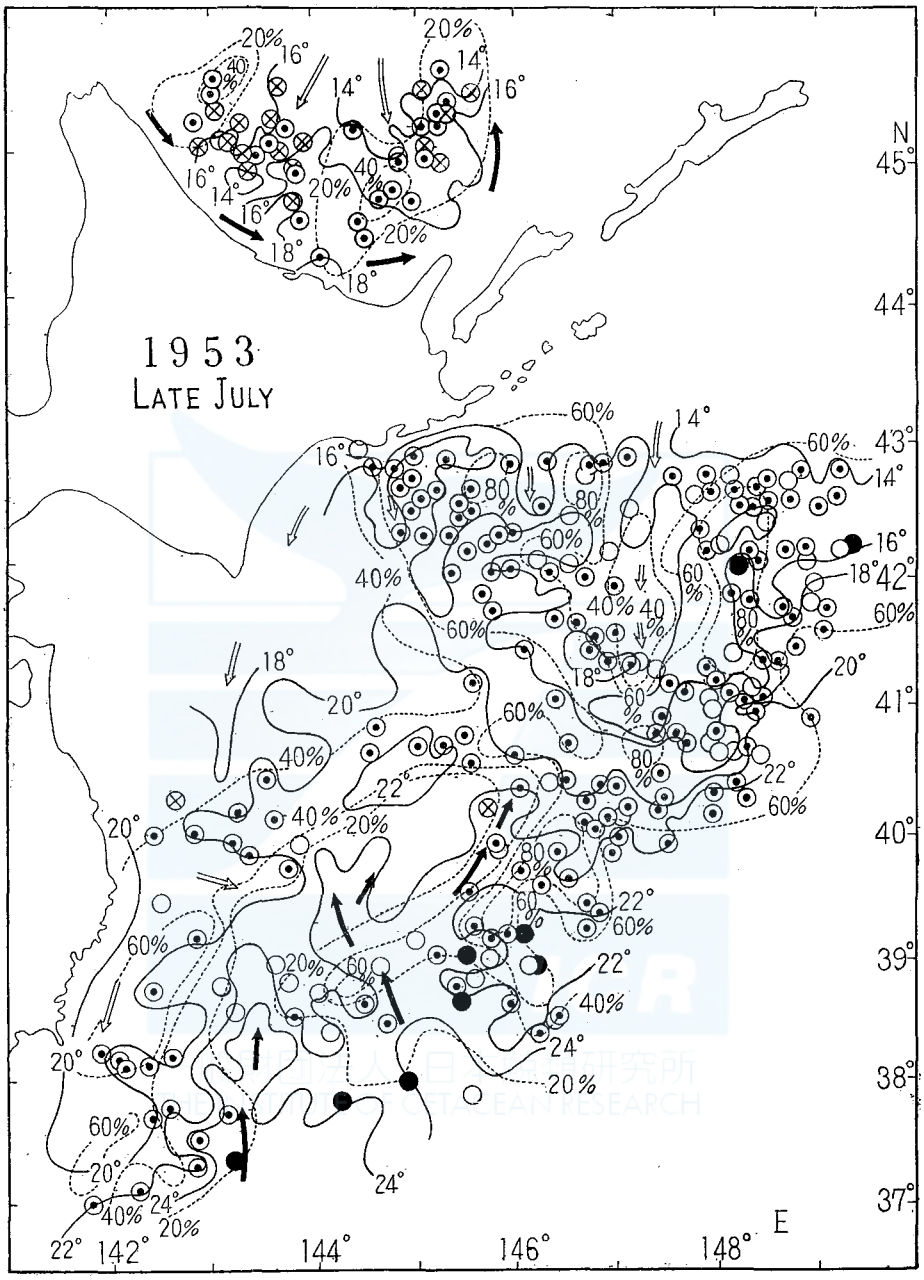

Fig. 4. (c) The distribution of whaling grounds in the North-Eastern Sea Region, water temperature, cold-warm water masses and sea-fog.
(Notice) Notations used in the map are the same as in Fig. 4 a.

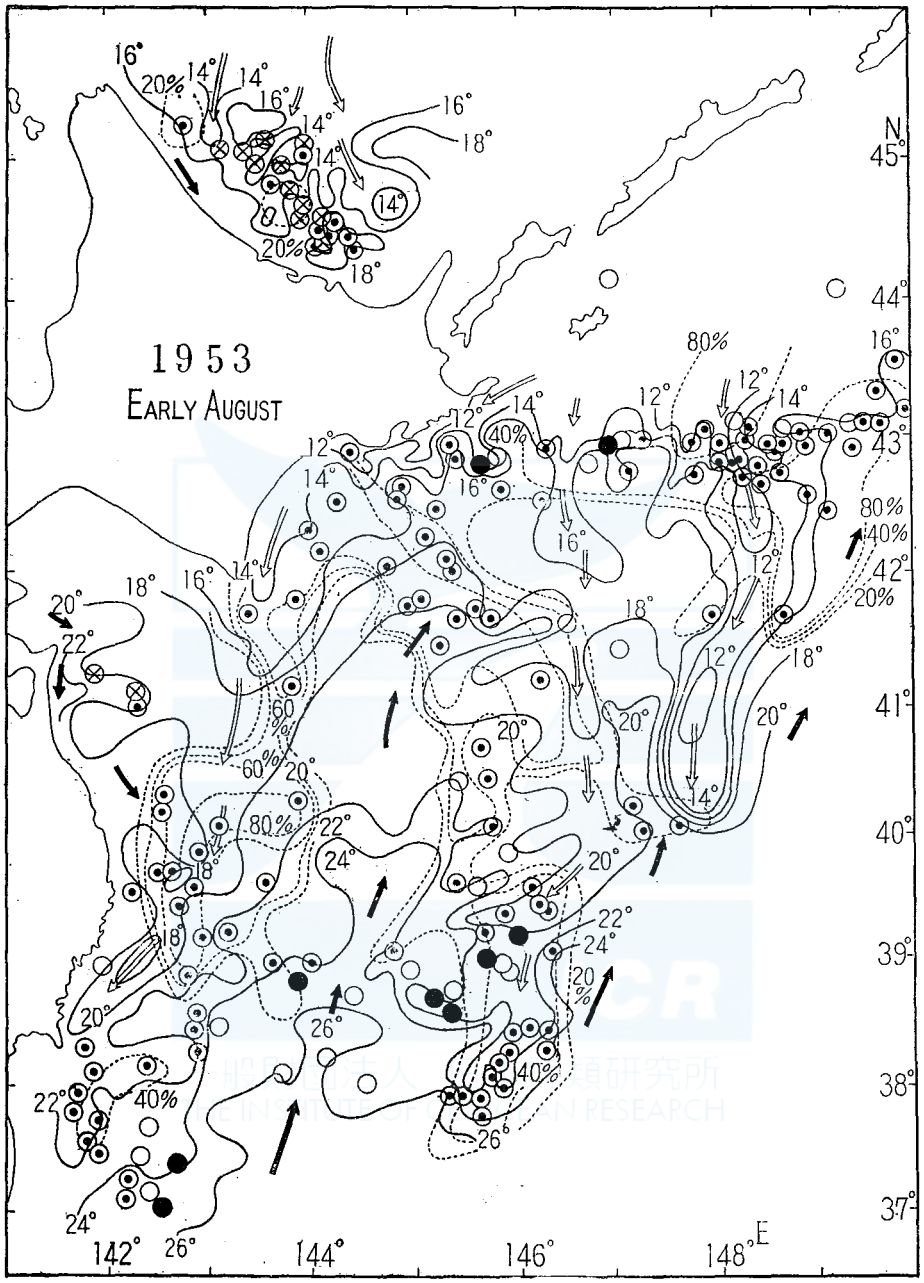

Fig. 4. (d) The distribution of whaling grounds in the North-Eastern Sea Region, water temperature, cold-warm water masses and sea-fog.
(Notice) Notations used in the map are the same as in Fig. 4 a.

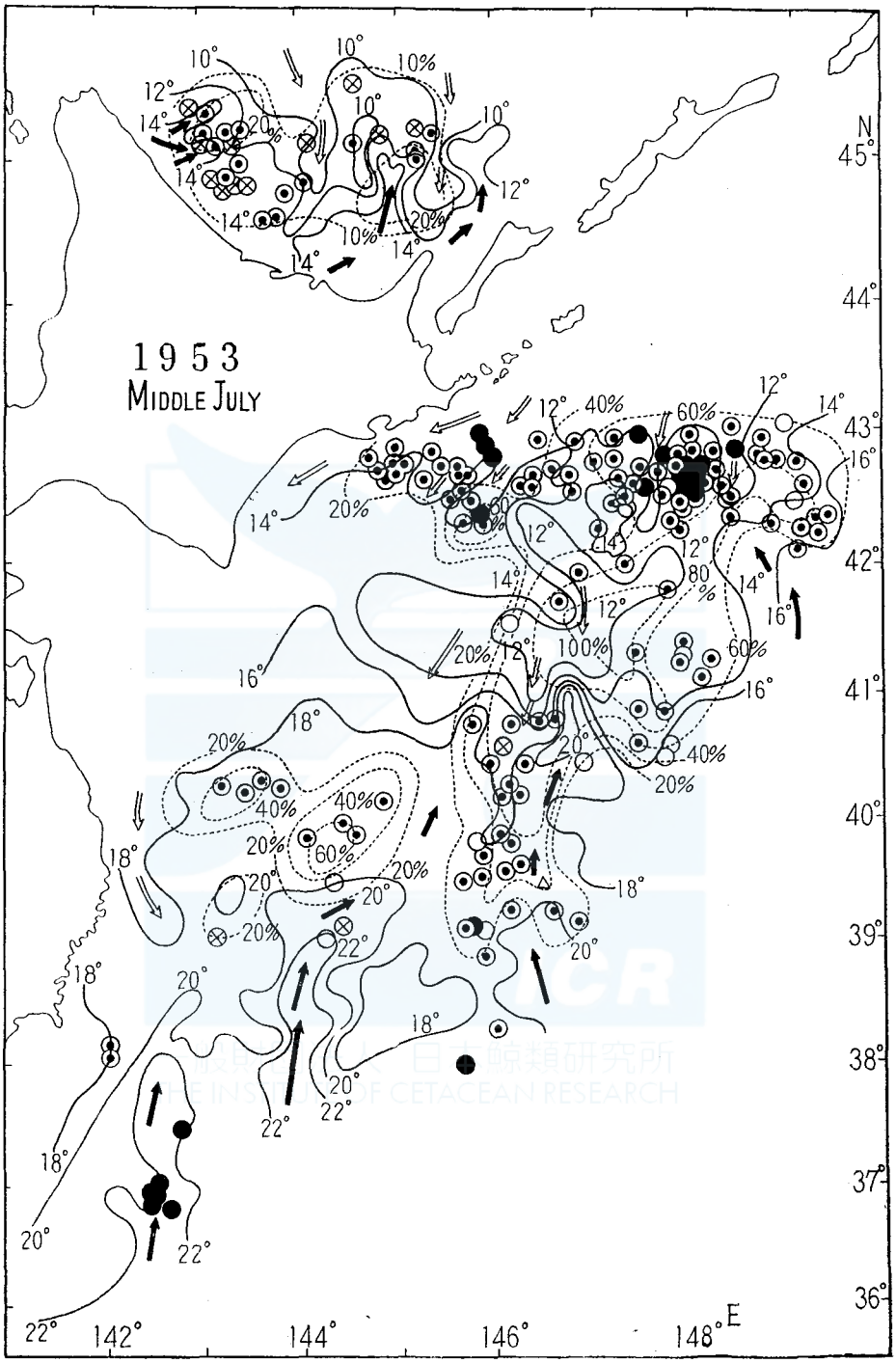

Fig. 4. (e) The distribution of whaling grounds in the North-Eastern Sea Region, water temperature, cold-warm water masses and sea-fog.
(Notice) Notations used in the map are the same as in Fig. 4 a.

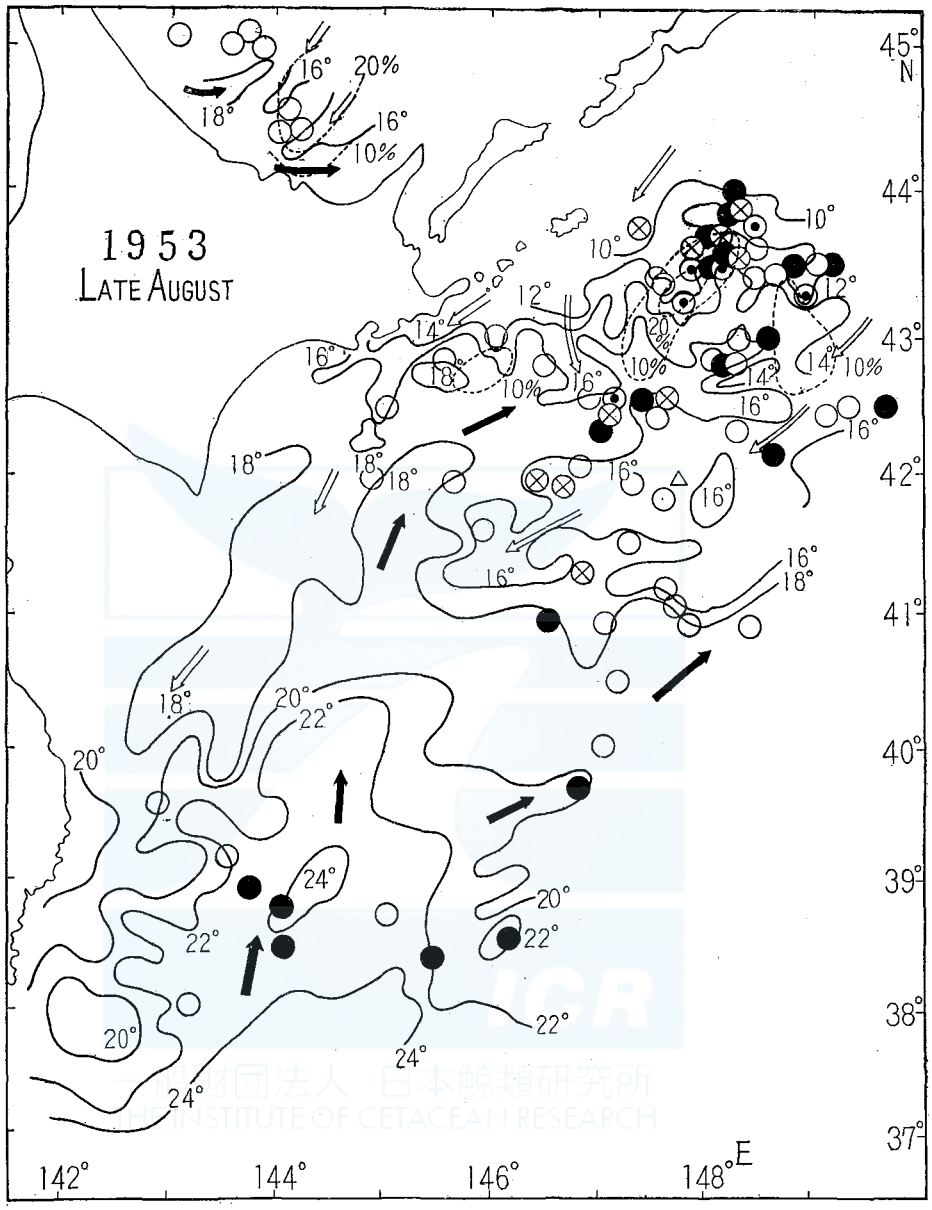

Fig. 4. (f) The distribution of whaling grounds in the North-Eastern Sea Region, water temperature, cold-warm water masses and sea-fog.
(Notice) Notations used in the map are the same as in Fig. 4 a.

ture lower than 20°C), Sea-fog occurs rarely in the zone near to Kurosiwo Front and also in the area of water temperature higher than 20°C. The rate of discovery for whales and the rate of gun-hit on whales are inversely proportional to the degree of visibility, consequently pro-

portional to the frequency of sea-fog occurrence.

During the occurrence of sea-fog the sea (wind-wave) is not rough in general. However, the shoals of whales found and the amount of the whale catch concentrate to the zone of plenty food organisms (such as squids for sperm whales, copepods and euphausia for fin-, sei- whales etc.) which has densely multiplied and assembled together.

In conclusion since the shoal of densely concentrated whales migrates there, notwithstanding the lower rate of discovery due to the bad visibility, the catch of whales increases consequently.

(2) Whaling Grounds in the Northern Pacific Ocean near Aleutian Islands in 1954 in Relation to the Weather Conditions.

By our inspection in tables 3, 4, 5, 6 and 7 (based on the data supplied by the Mother Whaling Ship Kinzyō-maru, Baikal-maru, the catcher boat Kōyō-maru and Seki-maru), we can find clearly the whale catch in the whaling season from middle May to middle September corresponding to the dense sea-fog season and the main whaling grounds lies at about dense sea-fog districts. The weather elements corresponding to the

Table 3. Number of Whale Caught for Each Weather Element in the Adj. Waters of Aleutian Is. in 1954. (The Whaling Mother Boat Kinzyō-maru)

Weather / Month	B	BC	C	O	F (Mist included)	D
May		5		39	14	1
June		36	34	216	175	29
July			23	201	80	
Aug.		16	8	84	134	
Total		57	65	540	403	30
Observed Chance		4	10	68	57	4
No. per Chance		14	6.5	8	7.2	7.5

Table 4. Number of Whales Caught for Each Weather Element in the Adj. Waters of Aleutian Is. in 1954. (The Whaling Mother Boat Baikal-maru)

Weather / Month	B	BC	C	O	F	D	Sum
May		22		23		1	46
June				190	65	11	266
July			24	177	98	32	307
Aug.		121		23	41	7	216
Sept.		48		157	37	12	250
Total		191	24	570	241	63	1085
Obs. Chance		22	2	86	40	12	
No. per Chance		8.7	12	6.6	6.0	5.2	

Table 5. The Difference betw. Air Temp. and Water Temp.
(Air Temp.-Water Temp.) °C.
(Kōyō-maru) (7. May–27. Sept. in 1954)

Weather / Month	B	BC	C	O	F	D	R
May		2.8	—	1.7	4.3	−1.3	—
June				2.9	3.7	3.6	
July				3.4	3.4	3.2	
Aug.		3.3	4.3	1.3	2.1	−0.7	−0.6
Sept.		2.9		2.4	1.3	2.1	3.5
Mean		3.0	4.3	2.3	3.0	1.4	1.5

Table 6. Number of Whales discovered in the Adj. Waters of Aleutian in 1954.
(The Catcher Boat Seki-maru)

Visibility / Month	1	2	3	4	5	6	7	8	9, 10
May	1	1	5	3	22	1	32	7	215
June	3	0	1	17	23	31	24	35	304
July	5	48	119	10	124	12	62	116	439
Aug.		12			3	1			226
Total	9	61 (70)	125	30 (155)	172	47 (219)	118	158 (276)	1284

Table 7. Number of Whales discovered in the Northern Waters in 1954.
(The Whaling Research Boat Kōyō-maru)

Species / Visibility	Fin	Sei	Humpback	Sperm	Blue	Sum (No. per each chance)
0	0	0	1	1	—	2 (1)
1	2	2	0	2	0	6 (2)
2	5	5	11	2	0	23 (3)
3	36	2	5	4	0	47 (2.5)
4	9	0	34	11	0	54 (4.5)
5	26	17	3	6	1	53 (2.6)
6	181	6	53	18	0	258 (7)
7	116	6	10	5	0	137 (6)
8	243	21	74	19	1	357 (6)
9	174	9	1	4	0	188 (24)
10	0	2	0	0	0	2 (1)
Total	792	70	192	72	1	

most frequent catch are overcast, cloudy, mist, fog, foggy drizzle in the period of (May), June, July, (Aug.), (Sept.). The whaling grounds were occupied mainly by fin whales, mingling with sperm whales and humpback whales. Of course the whale catch increases with the increase of visibility. In the case of Kōyō-maru shows its maximum in the range of visibility 6–9 Fin whale occupies its main part, and Humpback the next, Sperm whale and Sei whale in the same order, and in the case of Seki-maru the catch gradually increasing with visibility.

In this sea-region the difference between air temperature and water temperature is commonly 1°–4°C (about 3°C) and during the season June-July usually the value more than 3°C corresponding to the fog-region.

(3) The Distribution of Dichothermal Water and Whaling Ground in 1954. (See Fig. 5 a, b).

The author (M. Uda) studied recently the fluctuation of Oyasiwo current in relation to the atmospheric circulation and to the distribution of the (represented by the dichothermal water) dichothermal waters in

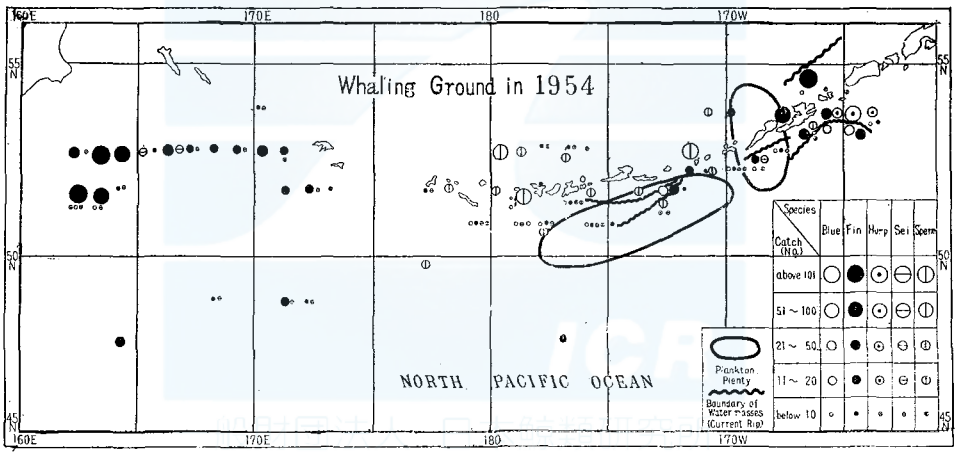

Fig. 5. (a) Whaling grounds in the Northern Sea-Region of the Pacific Ocean in 1954.

the north Pacific ocean during the years 1933–1953[3]. Glancing at Fig. 5 a, b for that in summer of 1954 in the adjacent waters of Aleutian Islands, we can recognize the main localities of whaling grounds lying at the fronts of the cold watermass and the mixed warm water mass, such western (I), central (II) and eastern (III) whaling grounds in the waters adjacent to Aleutian Islands, where planktons are abundant in those regions[4]. (See Fig. 5 b).

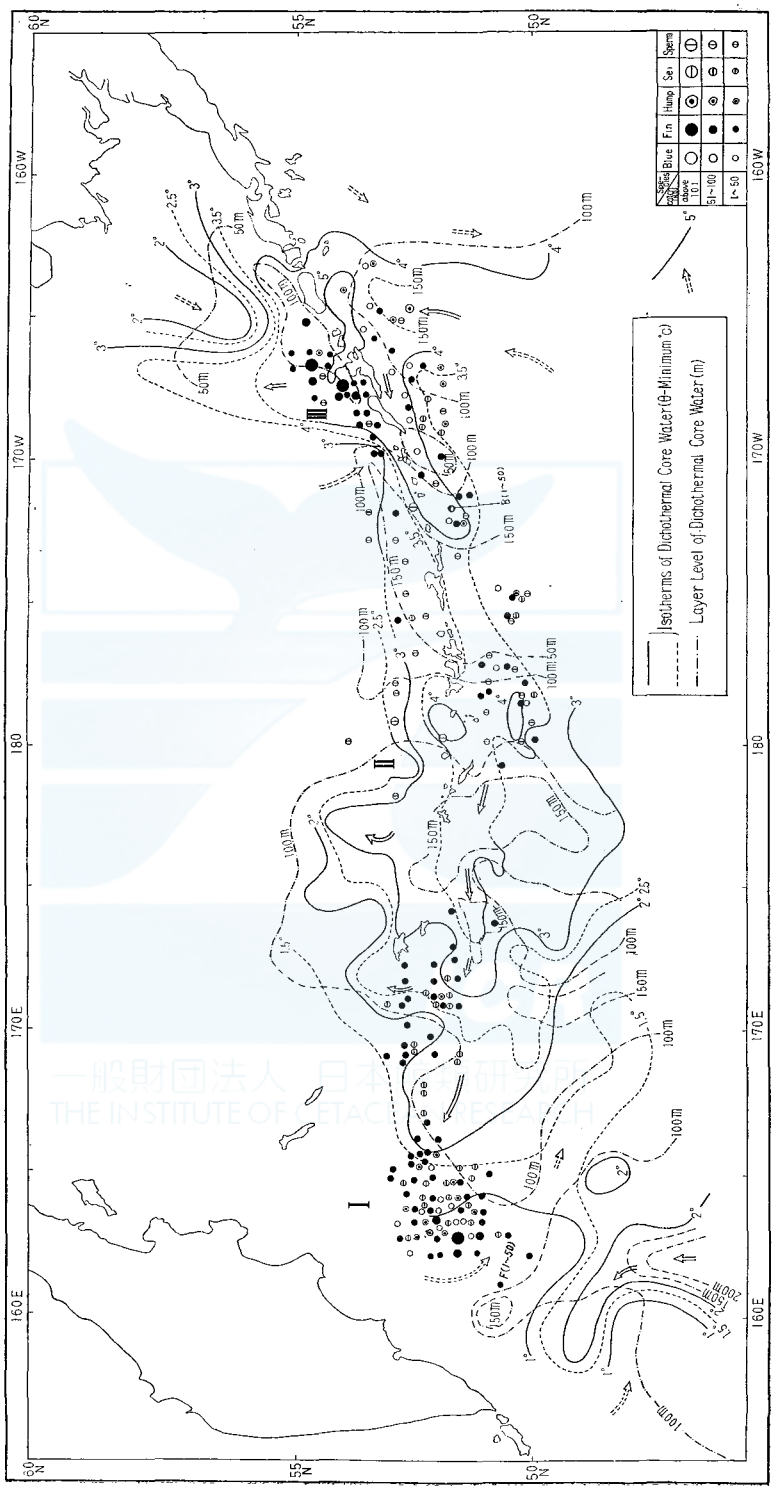

Fig. 5. (b) The distribution of dichothermal core water (θ-minimum °C), layer level of dichothermal core water (m) and localities caught in 1954.

Summary

(1) Cyclones hitted to the whaling grounds in the Northern Sea-Region of Pacific Ocean may be divided into two types i.e. (i) cyclones started from the Siberian Continent and (ii) those originated in the adjacent waters of Japan.

(2) In general, on the days adjacent to a day after the passage of cyclone it shows favourable whaling condition, and contrary to it adjacent to a day before the passage of cyclone it shows poor whaling condition.

(3) At first we established the relational formula on the amount of whale catch $F=K.V.S.O.$ and concluded the following: Shoaling condition of whales on the days after the passage of cyclone was better than that on the days before the passage of cyclone.

(4) Concerning whaling grounds in the North-Eastern Sea-Region of Japan we found the relative abundance of whales in the dense fog corresponding to the boundary zone of cold and warm waters.

(5) Generally whaling period in the Northern Pacific Ocean near Aleutian Is. corresponds to the dense sea-fog season and its main whaling ground lies at about denser sea-fog districts.

(6) Main localities of whaling ground in the adjacent waters of Aleutian Islands were found near at the boundary of the dichothermal water masses (intermediate cold water.)

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