STUDIES OF THE RELATION BETWEEN THE WHALING GROUNDS AND THE HYDROGRAPHIC CONDITIONS

III. THE AVERAGED CONDITIONS OF THE WHALING GROUNDS AND THEIR TRENDS OF VARIATION DURING 1946～55

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1. *Maps of Whaling Grounds.*

Recently we have plotted the maps of yearly whaling grounds in the adjacent waters of Japan during the late ten years (1946～'55) and its accumulated or averaged map of whale catch for each rectangle of 1° of longitude and latitude as shown in Figs. 2 and 3.

They indicate us the whaling grounds in the Tohoku Sea-region (North-Eastern Sea-region off Japan) lying along the *polar frontal-zone* in the north pacific, and particularly having two favourable core-grounds α, β in coincidence with the tops of the coastal Oyasiwo cold current and of the off-shore Oyasiwo cold current, respectively.

2. *Zonal and Meridional Trends of Distribution of Whale Catch.*

Over the area (35°–45°*N.*, 140°–150°*E.*) we have plotted the yearly curves of zonally summed (for each latitude φ) whale catch (N_φ) and meridionally summed (for each longitude λ) whale catch (N_λ) for each species (Sperm-Whale, Sei-Whale and Fin-Whale) during the above 10 years, as shown in Figs. 4, 5, 6 and 7.

From them we can easily find the trends of northerly shift and easterly offing extension of whaling grounds during the years, especially the remarkable variations of the distributions in the years of 1950～'55 compared to those of 1946～'49.

(1) In the case of Sperm-Whale, (Fig. 4) N_φ during 1946～'49 showing double max. of I. 37°–38°*N.* and II. 42°–43°*N* changed to N_φ during 1950～'55 showing almost single max. of II. i.e. the northern shift of whaling grounds corresponding probably to the prosperity of the offing north-going warm current.

Moreover N_λ during 1946～'49 limited to 141°～148°*E.* extended 142°～150°*E*, in the years 1950～'55, having its offing principal max. on 147°～148°*E* and coastal sub-max. of 142°～144°*E.*

The rate of easterly extension is about 2° longitude during 5–8 years i.e. from 145°–146°*E* in 1947～'48 to 147°～'148°*E* in 1952～'55.

(2) In the case of Sei-Whale (Fig. 5, 6), N_φ-curve during 1946～'49 showing double max. I. 37°–39°*N.*, II. 42°–43°*N* gradually changed to the

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single max. pattern during 1950～'55, showing the principal II. max, which indicates clearly the trend of northern shift of Sei-Whale grounds as before (1). Similarly N_λ-curve represents the tendency of easterly offing extension of grounds from the max. of 141°–147E. during 1946～'49 to the max of 145°–149°E during 1950～'55.

(3) In the case of Fin-Whale (Fig. 7) N_φ-curve showing the principal max. I (40°–43°N.) and secondary southern max. II (37°–39N.) during 1946～'49 changed to the pattern of I max. and new northern max. III (44°–45°N.) instead of the vanished max. II, which shows the northern shift of the whaling grounds.

N_λ-curve having the coastal max. of 141°–144°E and offshore max. of 145°–149°E, except the general offing tendency, indicate the concentrated Fin-Whale grounds near the frontal zone of the prevailing Tugaru Warm Current lying at NE off Hatinoe during the period of 1951～'55.

Inspecting those curves of $N(\lambda, \varphi)$, we can remark the seasonal trends of the whaling grounds (of Sperm-Whale and Fin-Whale) i.e. in the beginning (Apr., May) and end (Nov., Dec.) periods lying comparatively near the coast and during prosperous whaling season (from June to October) proceeding to the easterly offing and moreover during June-Sept. the center of gravity of whaling grounds proceeding to north and from Oct. coming down to south generally.

3. *The Variation Pattern of the Whaling Ground during the Former and Latter 5 Years of 1946～'55,*

After the World War II we have obtained 10 years data for whaling grounds now dividing them into the former-half sum (1946～'50)N_A and latter-half sum (1951～'55)N_B, we compared to each other and studied the variation during the periods.

(1) First as shown in Figs. 8, 9, 10 and 11, the time variation curves of each whale catch (sperm, fin-blue, and sei-whales) indicate generally the earlier coming of whaling catch N_B compared to N_A, in particular in spring season (about May).

Figs. 12, 13 and 14, show the distribution of whale catch for each whaling base station, which tell us the northern increase (such as off Kusiro in the waters of Hokkaido) compared to the remarkable southern decline (e.g. off Ayukawa, Kamaisi etc.). Those variations of whale catch are commonly remarkable after the year of 1950, which may correspond to the hydrographic change due to the prevailing north-going warm current.

(2) In order to clear up the circumstances we have constructed the difference maps of whale catch ($\Delta N = N_B - N_A$)

i.e. $\Delta N > 0_{(+)}$ means $N_B > N_A$ ····the increase of catch
$\Delta N = 0$ 〃 $N_B = N_A$ ····no change
$\Delta N < 0_{(-)}$ 〃 $N_B < N_A$ ····the decline of catch

as shown in Figs. 15, 16, 17 and 18, which indicate commonly the northerly offing (*SE* far off Kusiro and east far off Sanriku) increase against to the coastal and southerly decline (*SE* off Kinkazan), except the peculiar increase of fin-whale catch along the frontal zone of the Tugaru Warm Current.

4. *Probable Causes of the Variation*

The whaling intensity in the neighbouring waters of Japan increased remarkably in recent years as shown in Fig. 19, i.e. the tendencies of increasing ship-tonnage, ship-speed and the summed operational days may take warning to the over-fishing, inspite of the maintained total yields (see Fig. 20). The index numbers shown in the fig. 21 are referred to the standard of 1947. The coastal intense whaling and its disturbance of whale migration may contribute to the coastal decline and the offing exploration of the new whaling grounds. However, we should note the influence of hydrographical fluctuation of the growing warm current during the years from 1950 to 1955 which reflected to the increase of bluefin tuna and skipjack fisheries etc.

Both factors are important to the consideration of future prediction and conservation in addition to the efficient exploration of the whaling industry in Japan.

5. *The Optimum Water Temperature of Whaling Grounds.*

We have collected the surface water temperature records in the whaling grounds and compiled statistically in Figs. 1 and 21 and Table 1. Shoals of whales are found in the oceanic frontal zone where they can feed themselves on the plenty of food-animals and not so much influenced by water temperature.

Accordingly they swim in the waters of wide range for water temperature i.e. eurytherm in general. However, we can note some favourable temperature or optimum temperature for each whale species, as for example frequently Sei-Whale fonds of warmer water of about 14°–24°C (18°–24°C), and Sperm-whale in intermediate water of 12°–24°C (frequently 16°–22°C) Fin-whale in colder water of 10°–20°C (frequently 14°–18°C) seen.

In general in the North-Eastern Sea off Japan in winter (Jan.-Mar.) 8°–16°C, in spring (Apr.-June) 8°–20°C, in summer (July-Sept.) 14°–25°C, and in autumn (Oct.–Dec.) 10°–20°C are the favourable temperature to search the whaling grounds along oceanic frontal zone.

Concluding this paper we wish to state our sincere thanks to the aids of Miss Yukiko Ohtsuka for the computation and map construction during our researches.

TABLE 1. OPTIMAMUM WATER TEMPERATURE OF TOHOKU SEA-REGION WHALING GROUNDS. (1946～'55 AVERAGED)

Month, Decade	(Off Kusiro North)	Off Kinkazan (South)	Remarks
Jan. Early	—	Sp. 12°—16°C	Sp (8°—11°C)
〃 Middle	—	〃 8°—16°C	
〃 Late	—	〃 Ca 12°C	
Feb. Early	—	〃 10°—14°C	
〃 Middle	—	〃 12°—15°C	→ Off Kumano Nada Sp. 14°—15°C 〃 〃 17°—18° 〃 〃 15°—18°
〃 Late	—	〃 10°—15°C	
Mar. Early	—	〃 5°—13°C	
〃 Middle	—	〃 8°—12°C	
〃 Late	—	〃 12°—13°C	
Apr. Early	Sp. 2°—6°C	〃 7°—16°C	
〃 Middle	〃 2°—8°C	〃 8°—16°C	Whaling grounds moving to North.
〃 Late	—	〃 4°—16°C	
May Early	〃 2°—8°C	〃 10°—18°C	
〃 Middle	〃 4°—12°C	〃 14°—20°C	Off Kusiro (2°—16°C)
〃 Late	〃 6°—12°C	〃 16°—20°C	
June Early	〃 4°—10°C	〃 14°—20°C	Off Kiukazan (7°—22°C)
〃 Middle	〃 8°—16°C	〃 16°—22°C	
〃 Late	〃 8°—16°C	〃 16°—22°C	
July Early	〃 8°—18°C	〃 20°—22°C	Center of Gravity of Whaling grounds lying off Kusiro. (8°—22°C) off Kinkazan (18°—26°C)
〃 Middle	〃 12°—14°C	〃 18°—22°C	
〃 Late	〃 14°—22°C	〃 22°—26°C	
Aug. Early	〃 15°—22°C	〃 22°—26°C	
〃 Middle	〃 16°—22°C	〃 22°—26°C	
〃 Late	〃 13°—20°C	〃 22°—25°C	
Sept. Early	〃 15°—22°C	〃 22°—25°C	
〃 Middle	〃 12°—20°C	〃 22°—24°C	
〃 Late	〃 10°—18°C	〃 20°—25°C	
Oct. Early	〃 10°—16°C	〃 18°—22°C	
〃 Middle	〃 10°—16°C	〃 18°—22°C	Whaline grounds moving to South, its centre of gravity shifted to the offing of Kinkazan. off Kusiro (4°—16°C) off Kinkazan 12°—22°C
〃 Late	〃 10°—15°C	〃 18°—22°C	
Nov. Early	〃 8°—13°C	〃 18°—22°C	
〃 Middle	〃 6°—12°C	〃 14°—22°C	
〃 Late	〃 12°—14°C	〃 14°—20°C	
Dec. Early	〃 8°—12°C	〃 14°—19°C	
〃 Middle	Ca 4°C	〃 14°—20°C	
〃 Late	—	〃 12°—16°C	

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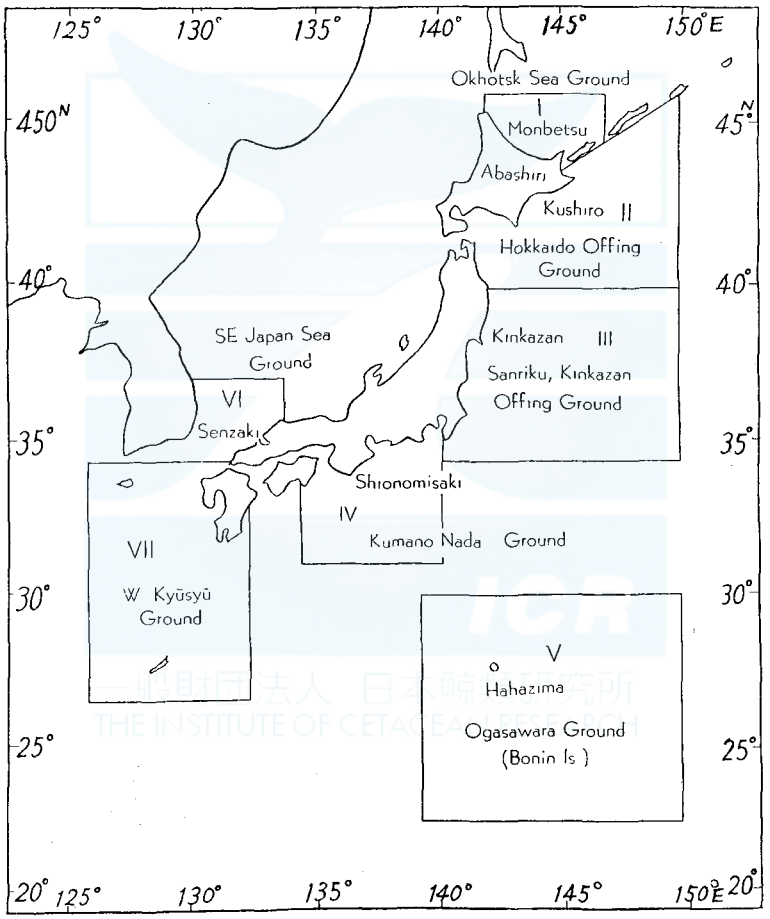

Fig- 1. Sea region of whaling grounds.

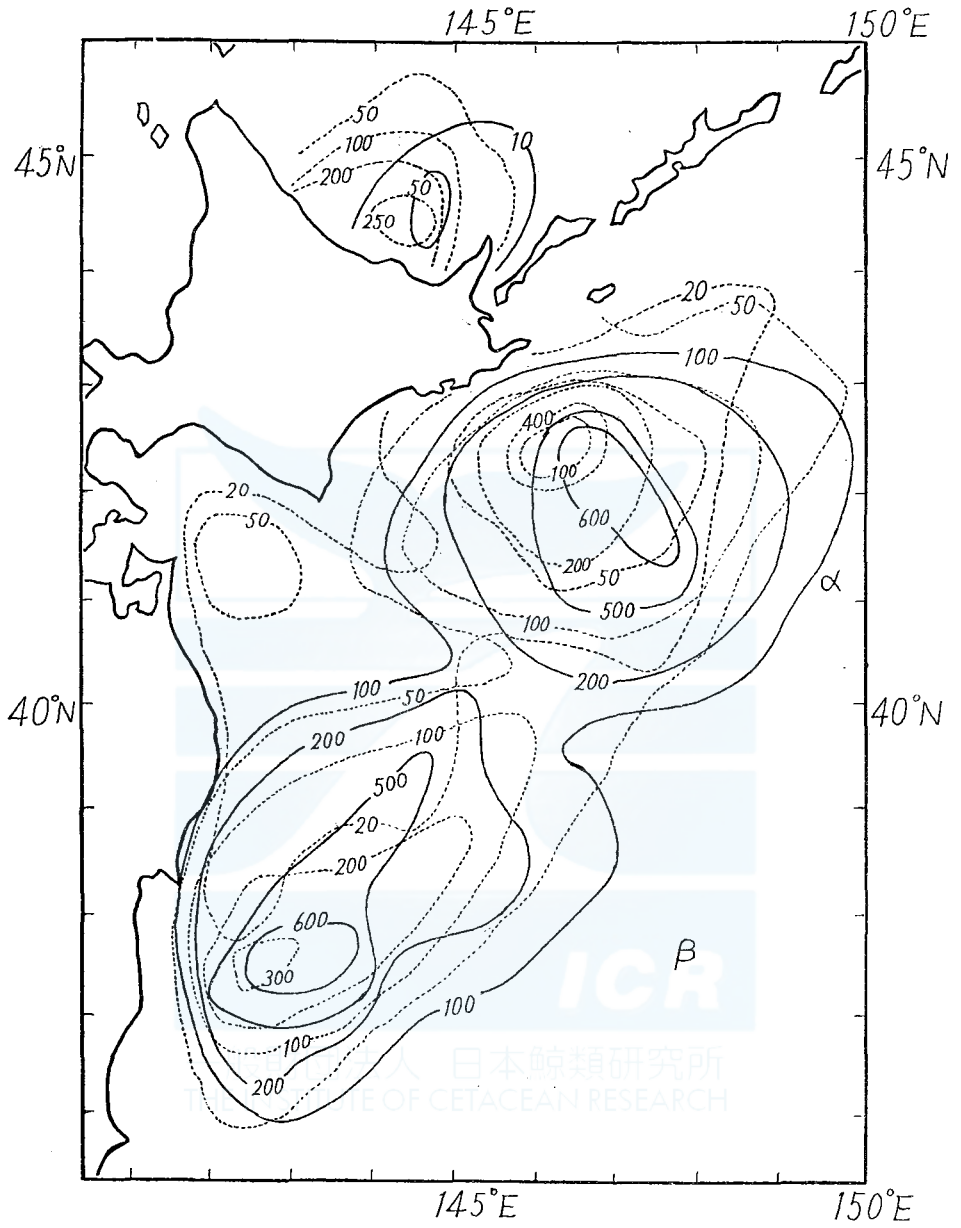

Fig. 2. Whaling grounds in the 10 years of 1946–55 Solid line: sperm whales. Broken line fine whales. Dotted line sei whales

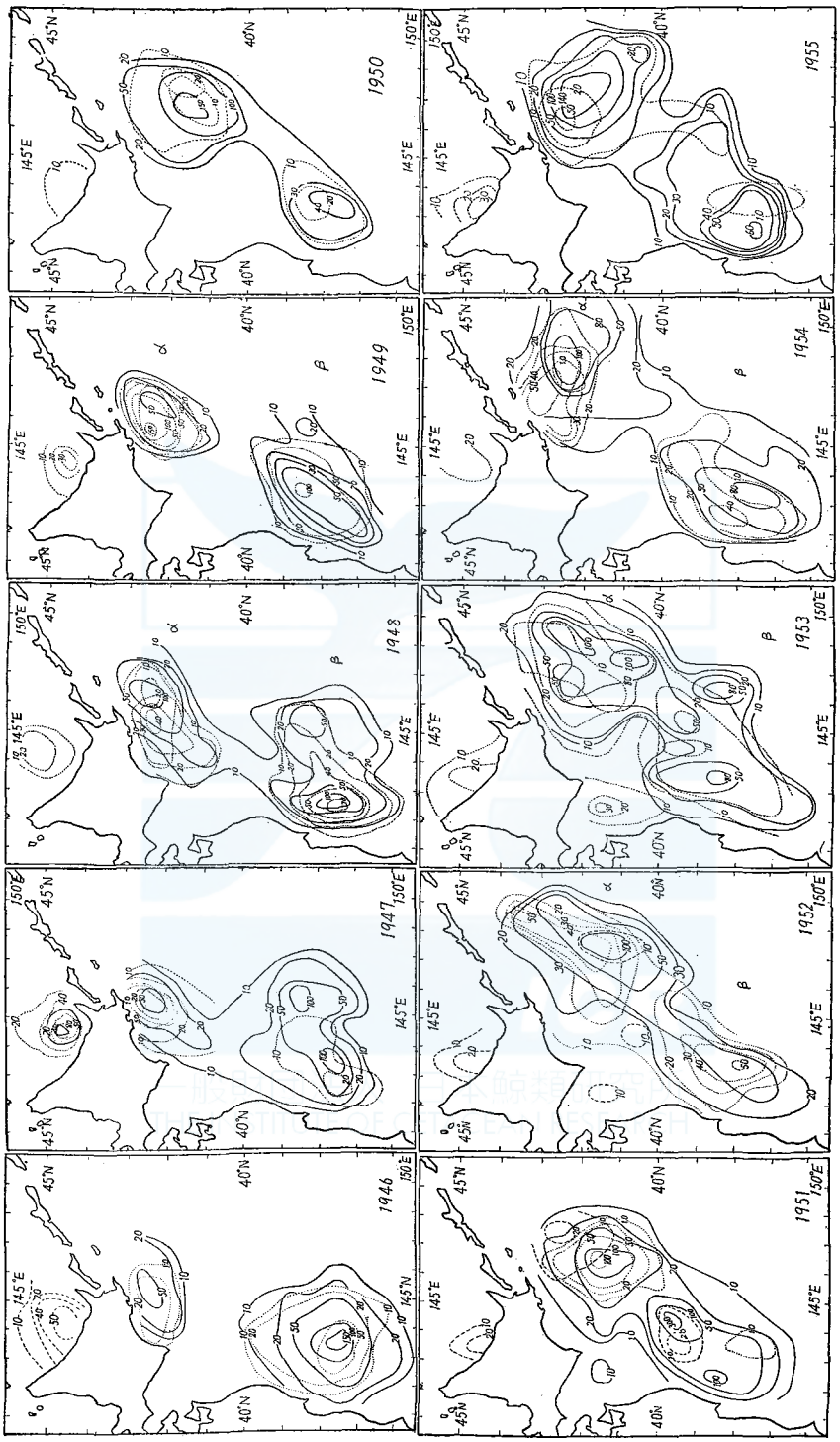

Fig. 3. Whaling grounds from 1946 to 1955. Solid line: sperm whales. Broken line: fin whales Dotted line: sei whales.

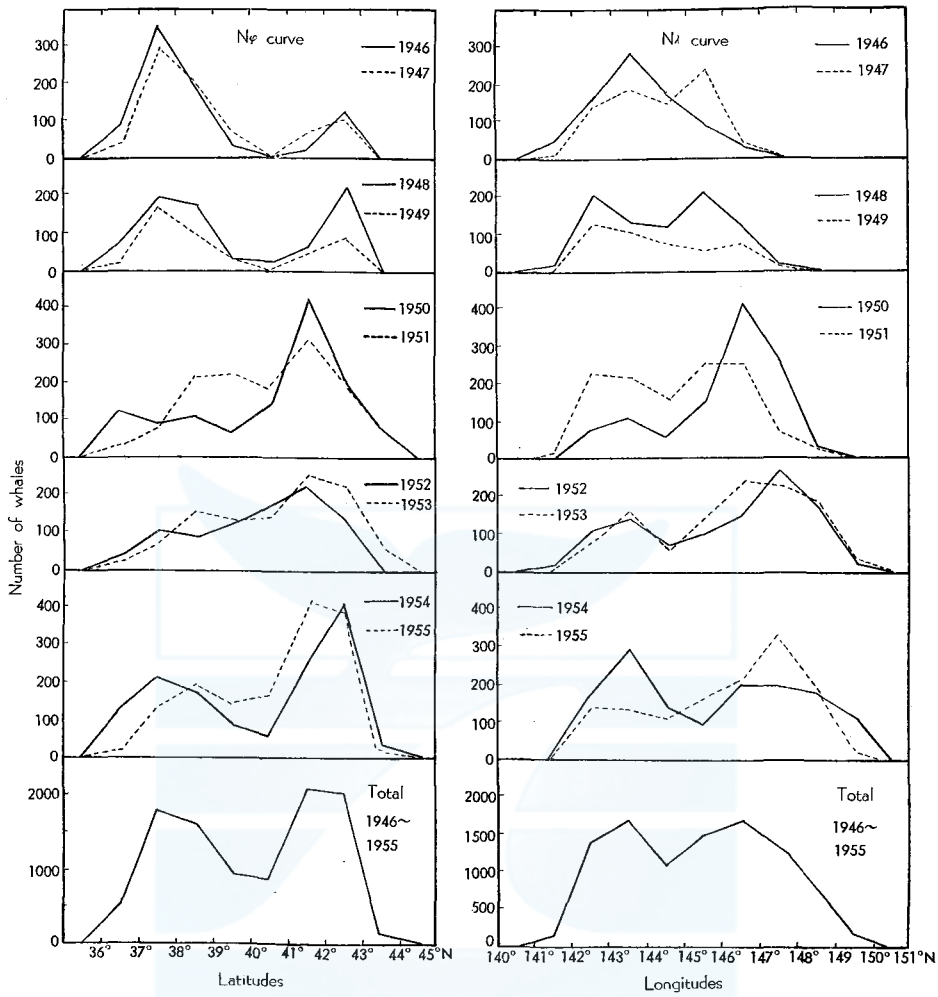

Fig. 4. $N\varphi$ and $N\lambda$ curves of sperm whales from 1946 to 55

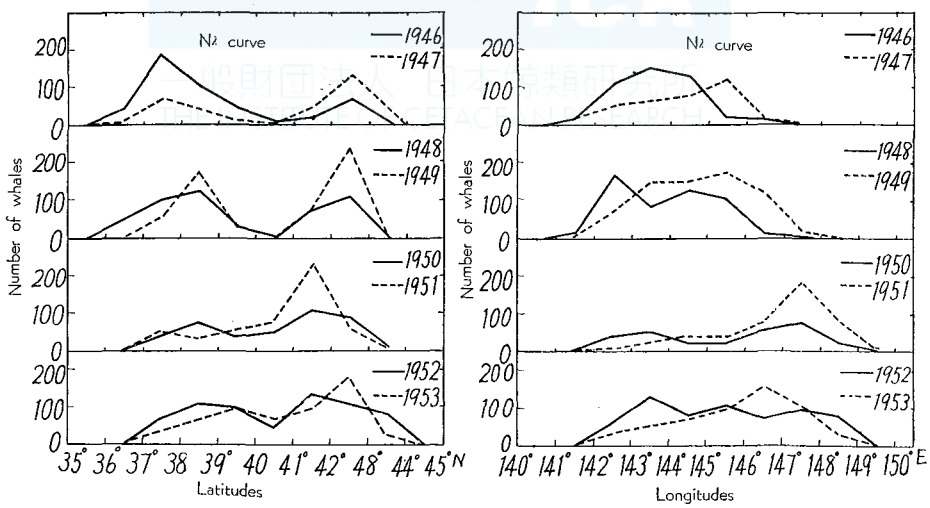

Fig. 5. $N\varphi$ and $N\lambda$ curves of sei whales from 1946～'53

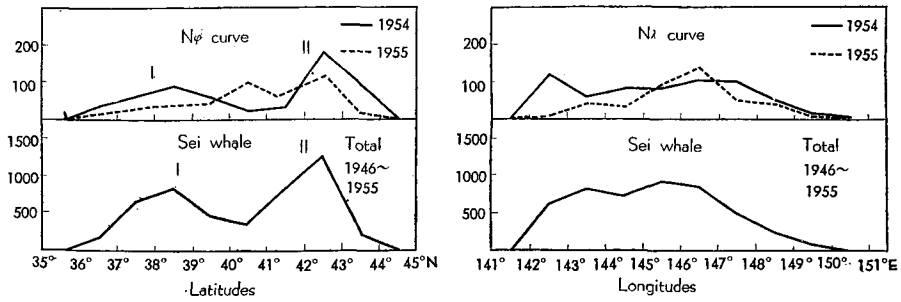

Fig. 6. $N\varphi$ curves and $N\lambda$ curves of sei whales from 1954 to '55.

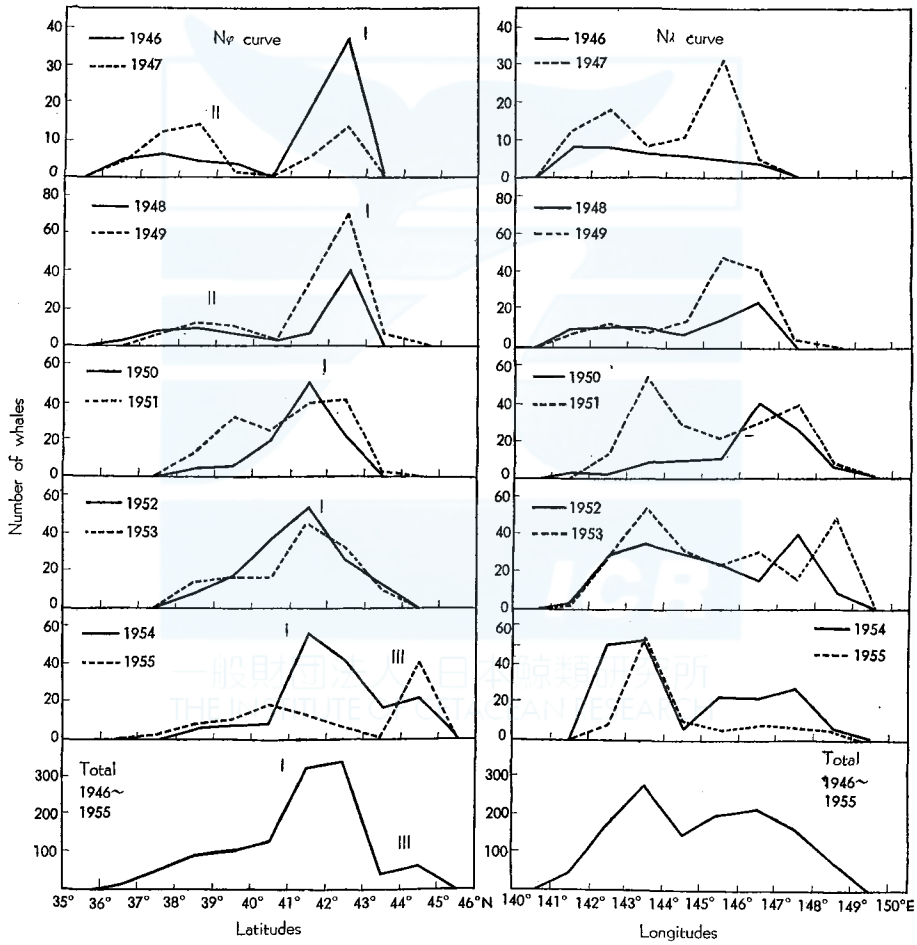

Fig. 7. $N\varphi$ curves and $N\lambda$ curves of fin whales from 1946 to '55.

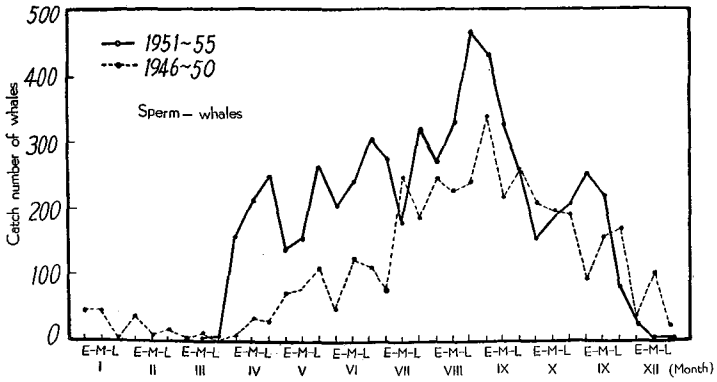

Fig. 8. Number of canght sperm whales in each month.

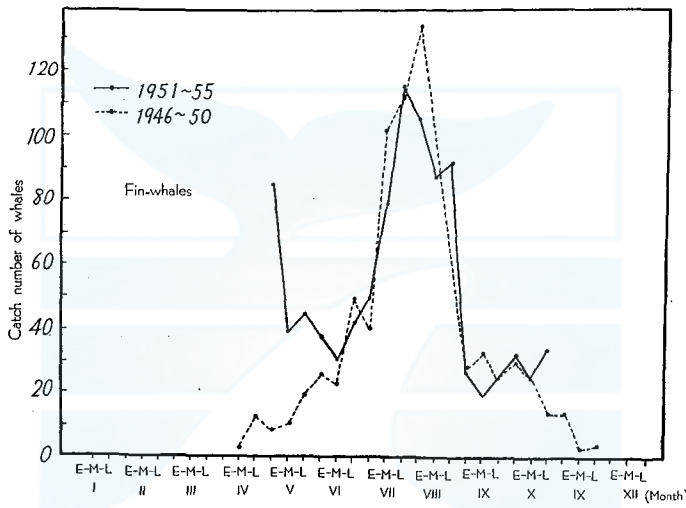

Fig. 9. Number of canght fin whales in each month.
E....Early M....Middle L....Late

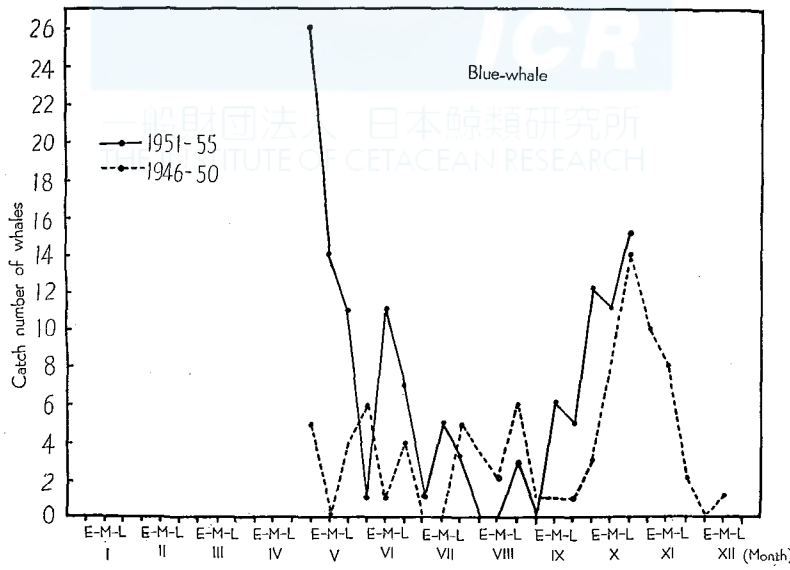

Fig. 10. Number of caught blue whales in each month.

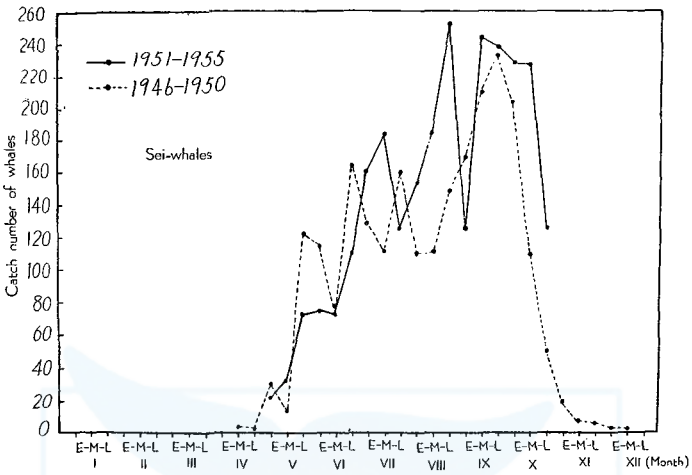

Fig. 11. Number of caught sei whales in each month.

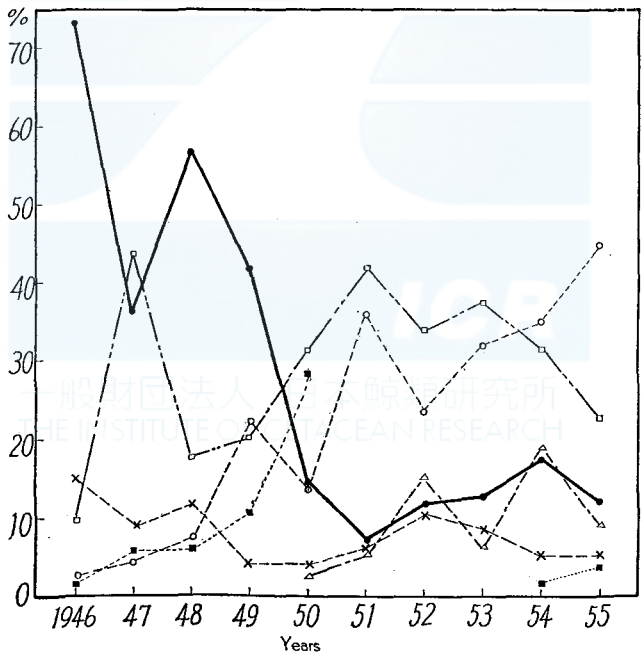

Fig. 12. Number of caught sei whales in each month.
E...Early M...Middle L...Late

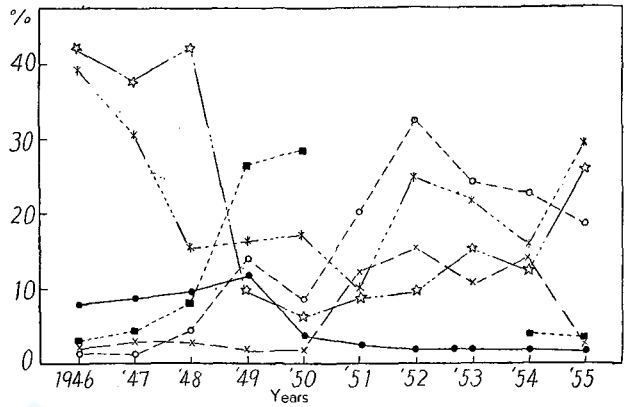

Fig. 13. Catch constitution of each land stations fin whales.

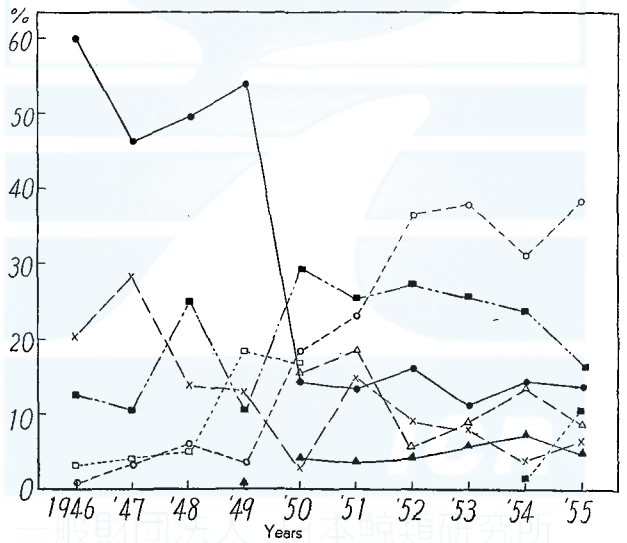

Fig. 14. Catch constitution of each land stations sperm whales.

A ····Kushiro.
B ····Ayukawa.
C ····Atsukeshi.
D ····Kiritatsupu.
E ····Kamaisi.
F ····Onagawa.
G ····Oosawa.
} From the offing of sanriku to the offing of Hokkaido.

H ····Abashiri.
I ····Monbetsu.
} Okhotsk sea region.

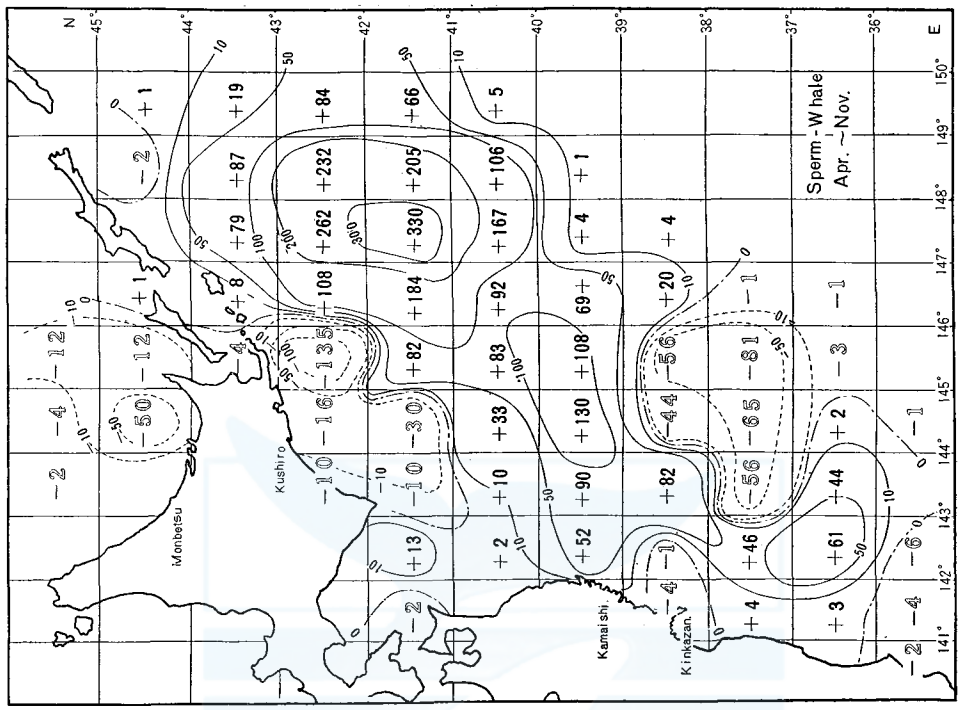

Fig. 16

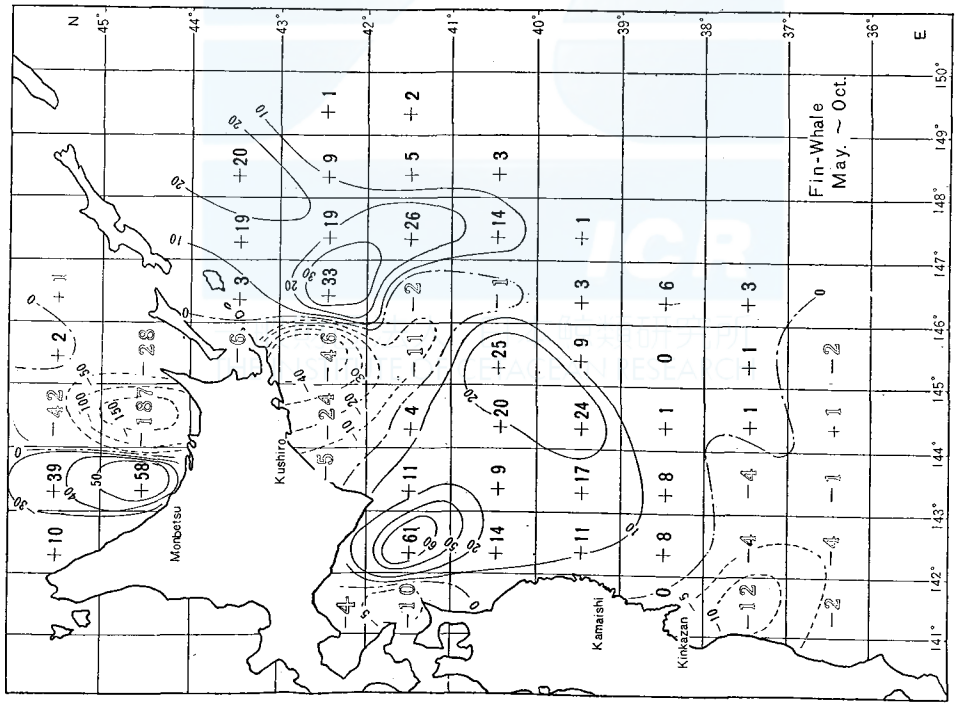

Fig. 15

Figs. 15–16. The variation map of whale catch during the former and latter 5 years of 1946–45.

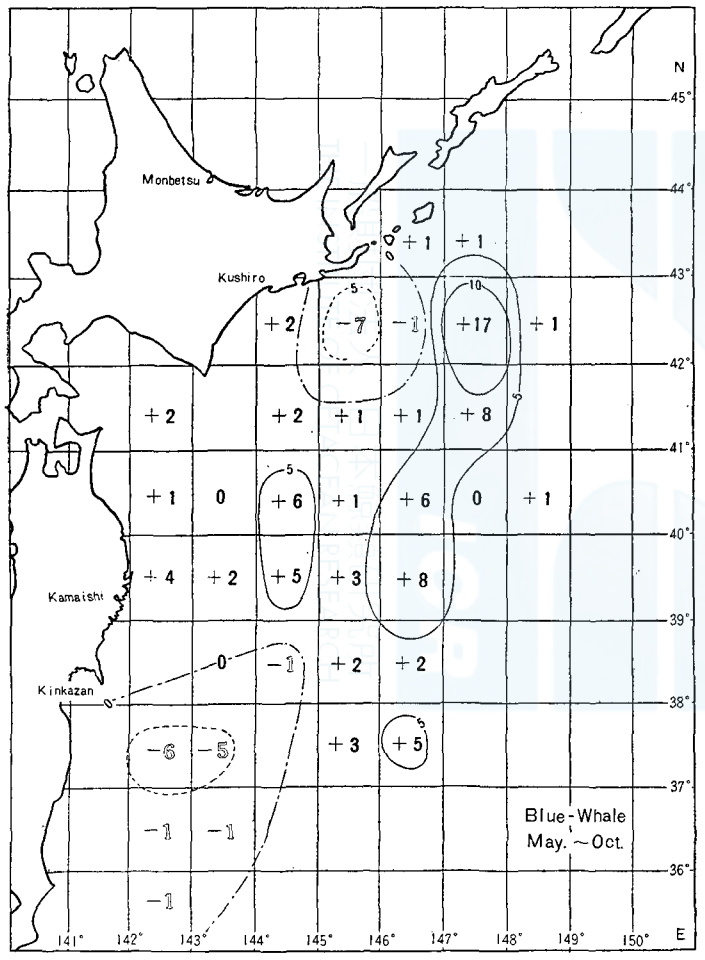

Fig. 17.

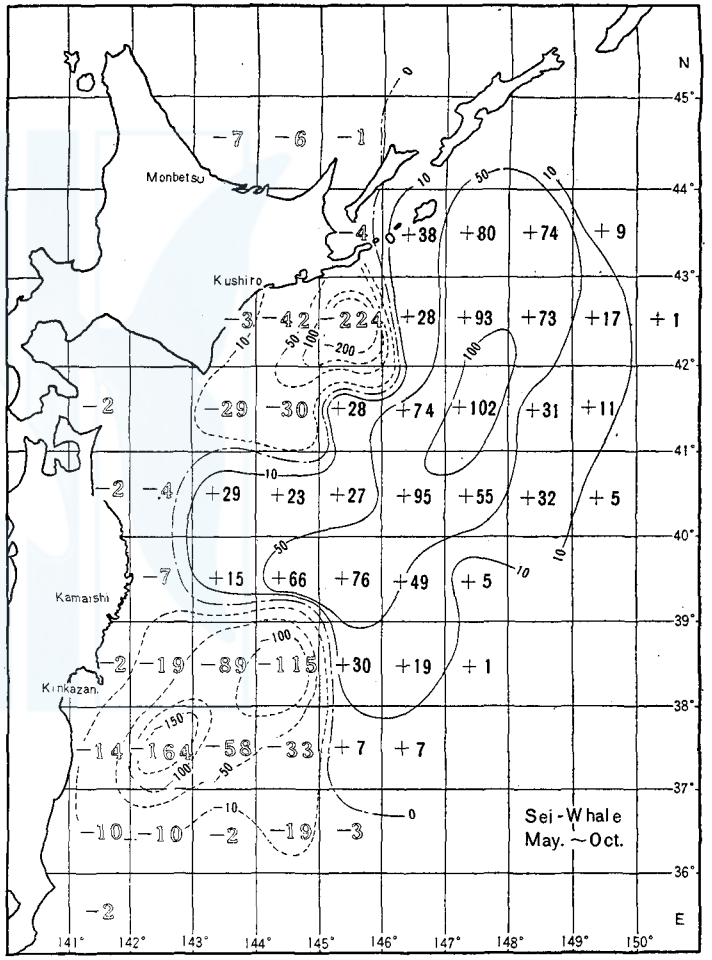

Fig. 18.

Figs. 17–18. The variation map of whale catch during the former and latter 5 years of 1946–45.

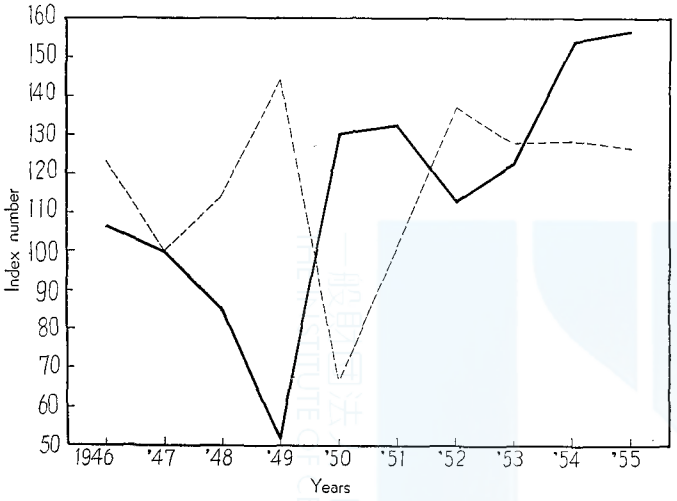

Fig. 19. The trends of waling effort referred to that in the year of 1947.

——— Sperm whale - - - - - Baleen whale

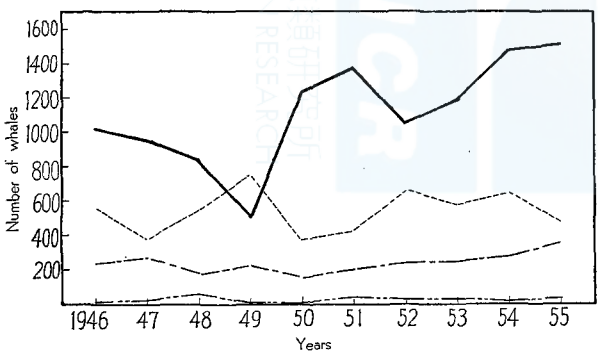

Fig. 20. Number of cautght whales in each year.

——— Sperm whale - - - - - Sei whale

—·—·— Fin whale —··—··— Blue whale

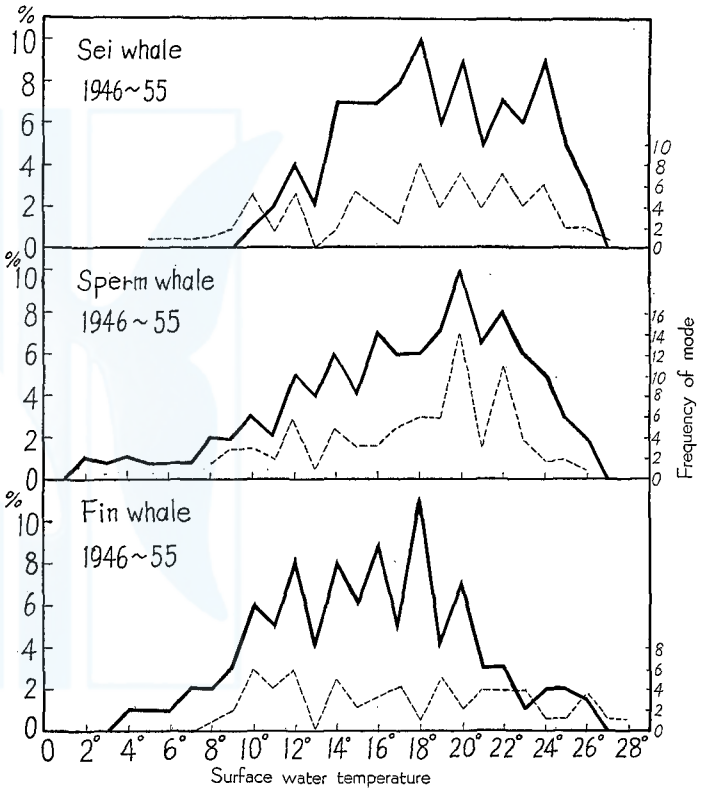

Fig. 21. Number of whales in each year.