Cruise Report of the Japanese Whale Research Program under a Special Permit in the North Pacific (JARPN) in 1997

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ABSTRACT

The fourth Japanese Whale Research Program under Special Permit in the North Pacific (JARPN) was conducted in parts of sub-areas 9, 8 and 7 from 6 May to 14 July 1997. Three sighting /sampling vessels (SSVs) and one research base were engaged in the research. One dedicated sighting vessel (SV) was allocated independently. A total of 12,155.5 n.miles was searched by the three SSVs and 143 schools/ 149 individuals of minke whales were sighted. The SV covered 2,907.6 n.miles, and made the sightings of 3 schools/ 3 individuals of minke whales. A total of 144 minke whales were targeted for sampling resulting in the catch of 100 individuals (67 from sub-area 9, two from sub-area 7E and 31 from sub-area 8). Similar to previous surveys, large males dominated in the collected sample. However, it was noted that most of immature animals and female animals were collected in sub-area 9 and more than half of females (5 immature, 2 pregnant) were obtained in May, suggesting early seasonal migration or passage of females to the research area. The main prey species of minke whale in sub-area 9 was Japanese anchovy but Pacific saury was the main prey species in sub-area 8. Trials for attachment of satellite tag to minke whale were conducted, however, no positive results were obtained. Natural markings of four blue whales, four humpback whales and one right whale were photographed and skin biopsy samples from a fin whale and a humpback whale were obtained.

INTRODUCTION

The International Whaling Commission /Scientific Committee (IWC/SC) established a Working Group on North Pacific Minke Whale Management Trials in 1993, which started the RMP implementation simulation trials in which whales distributed around Japan. The Working Group did not adopt the hypothesis that there exist two separate stocks of minke whales in the western side of North Pacific, i.e., J and O stocks denominated by the IWC. Instead, they divided the J and O stocks into seven sub-stocks and added a Western North Pacific stock (W stock), which would be distributed in offshore areas (IWC,1994). There were, however, questions regarding the validity of these assumptions (Hatanaka *et al.*, 1994).

The Japanese Whale Research Program under a Special Permit in the North Pacific (JARPN) was designed by the Government of Japan with the purpose to elucidate stock structure of minke whales distributed in the area surrounding Japan. The research plan was submitted to the IWC/SC in 1994 (Government of Japan, 1994). The JARPN surveys had been performed in sub-area 9 in 1994 and 1995 (Fujise *et al.* 1995, 1996) and in sub-areas 7, 8 and 11 in 1996 (Fujise *et al.* 1997). From the results of analysis of the data and samples obtained from 121 whales sampled in sub-area 9, the Working Group which met again in 1996 agreed that no evidence was available supporting the occurrence of a W stock in offshore waters. However, the group also noted that the seasonal coverage of the sampling in sub-area 9 did not include the period from April to May. Furthermore large portions of sub-areas 8 had not been sampled. Then the group suggested that the information presented did not preclude the occurrence of a W stock either (IWC, 1996).

This paper reports the fourth cruise of the JARPN, which was conducted from 6 May to 14 July 1997 in sub-areas 8, 9 and eastern part of 7.

RESEARCH METHODS

1. Research area

Research area in the present survey was composed of three of the 13 sub-areas established by the IWC/ SC: sub-area 9 (north of 35° N, 157° E-170° E), sub-area 8 (north of 35° N, 150° E-157° E) and eastern part of sub-area 7 (north of 35° N, west of 150° E), excluding 200 n.miles zone of the United States and Russia (Fig.1). The eastern part of sub-area 7 (sub-area 7E) was defined taking into consideration the previous design of Japanese sighting surveys, which divided the sub-area by a boundary connecting the following points: 35° N, 143° E; 40° N, 145° E; 42° N, 146° 32'E.

2. Research vessels

Three vessels, *Kyo Maru No.1* (K01; 812.08 GT), *Toshi Maru No.25* (T25; 739.92 GT) and *Toshi Maru No.18* (T18; 758.33 GT) were engaged in sighting and sampling surveys. *Nisshin Maru* (NM; 7,198GT) acted as a research base and engaged in all biological survey on collected samples and XBT survey. *Kyoshin Maru No.2* (KS2; 361.00 GT) was dedicated in sighting survey independently.

3. Cruise track line

Construction method of the cruise track line was similar in some aspects to the previous research (Fujise *et al.* 1997). In this survey, track line of the sighting/ sampling vessels (SSVs) for the main survey was designed on the basis of surface water temperature data obtained from the latest chart reported by the Japan Fisheries Information Service Center to target the areas where density of minke whale should be high. Moreover, a separate track line was designed as Special Monitoring Survey (SMS) in limited areas where the highest density of minke whales was expected (Fig.2a). Track line for the sighting vessel (SV) was designed to survey the whole research area as even as possible (Fig. 2b). In addition, the SV was also engaged in finding the areas where the density of minke whale distribution was high, in advance for survey of SSVs.

4. Sighting and sampling

Sighting and sampling procedure were as in the previous JARPN surveys (Fujise *et al.* 1996, 199·). The sighting survey was conducted under closing mode (when a sighting was made on he predetermined track line, the vessel approached the whale and species and school size were onfirmed). Three SSVs followed parallel track lines 6 n.miles apart (4 n.miles in SMS), at a standard speed of 10.5 knots. The survey of the SSVs used two sighting modes, BC and BS modes. The survey on BC mode were operated under optimal research conditions (when the Beaufort scale was below 4 and visibility was over 2 n.miles). The survey on BS mode were operated under worse sea condition but sampling of minke whales was possible. The survey of the SV used only BC mode. Closing was conducted for sightings of minke whales or whales suspected to be minke whales. In addition, both SV and SSVs approached blue, fin, right and humpback whales for conducting some experiments.

All minke whales sighted by SSVs and the research base were targeted for sampling. In the case of schools of two or more, sampling order was decided randomly by use of random numbers table (Kato *et al.*, 1989) . Considering the difficulty to collect minke whales compared with the situation in the Antarctic, occasionally two or three SSVs operated together to collect a school of minke whale, in the same way as in the previous JARPN survey (Fujise *et al.* 1996).

5. Experiments

Sighting distance and angle experiment

This trial was conducted in order to evaluate the accuracy of the information on sighting distance and sighting angle given by observers of the SV and SSVs.

Observation of behavior patterns of blue and fin whales

This trial was conducted in order to collect information on natural behavior of blue and fin whales, especially to diving time and swimming direction.

Photo-identification experiment

The following species were targeted for photographic record of natural markings; blue, humpback and right whales.

Biopsy sampling

The species targeted for photo-identification experiment and additionally fin and minke whales were targeted for skin biopsy sampling.

Satellite tagging experiment

Attempts to attach a satellite tagging system (Nishiwaki *et al.*, 1994) to the body of a minke whale were made to elucidate migration routes.

Oceanographic survey

XBT profiles were obtained from NM in the research areas. Marine debris were recorded from NM during transit between the research area and Japan. Also all marine debris found in stomachs of minke whales were recorded and collected.

OUTLINE OF THE RESEARCH ACTIVITIES

An outline of the research activities conducted during the 1997 JARPN survey is as follows.

Date	Event
1 May	NM and SSVs departed from Japan (NM from Taura port and SSVs from Shimonoseki port).
2 May	SSVs started sighting survey in transit area.
5 May	SSVs finished sighting survey in transit area.
6 May	SSVs started sighting/sampling survey in sub-area 9.
9 May	SV departed from Japan (from Taura port).
10 May	SV started sighting survey in transit area.
14 May	SV finished sighting survey in transit area.
15 May	SV started sighting survey in sub-area 9.
19 June	SSVs finished sighting/sampling survey in sub-area 9.
22 June	SSVs started sighting/sampling survey in sub-area 7E.
27 June	SSVs finished sighting/sampling survey in sub-area 7E.
28 June	SSVs started sighting/sampling survey in sub-area 8.
1 July	SV finished sighting survey in sub-area 9 (with an interval between 6-16 June) and started sighting survey in sub-area 8.
8 July	SV finished sighting survey in sub-area 8 and started sighting survey in transit area.
10 July	SV finished sighting survey in transit area.
11 July	SV arrived at Japan (Shiogama port).
14 July	SSVs finished sighting/sampling survey in sub-area 8.
16 July	SSVs conducted sighting survey in transit area.
18 July	NM arrived at Japan (Tokyo port).
19 July	SSVs arrived at Japan (Shimonoseki port).

Although the tracklines for SV was planed to survey the whole research area preceding SSVs, actually it could not survey sub-area 7E because of its role of foods supply and exchange of crews for NM.

RESULTS

1. Searching effort

Table 1 shows the searching distances (n.miles) and the number of minke whales sighted by searching mode and sub-area. Most of the searching effort of SSVs was applied between 38° N and 40° 30'N in sub-area 9, 39° 30'N and 40° 30'N in sub-area 7E, and 41° N and 42° 30'N in sub-area 8 (Fig.2a). These zones presented surface water temperature on which minke whales were found in previous JARPN surveys. On the other hand, the searching effort of SV was distributed in the research area as even as possible (Fig. 2b). In sub-area 8, the searching effort in the SMS was higher than in the ordinary survey.

The proportion of searching distances under BS mode was high in sub-areas 8 (ordinary survey) and 9 (SMS). The cause of worse sea condition was different among each sub-area. In sub-area 9 (pelagic waters), strong wind (over 17 knots) were common. Low atmospheric pressure was the most frequent cause of bad weather (30.2% of all weather record). However, in sub-area 7E (adjacent waters), poor visibility (under 2 n.miles) due to dense fog was frequent (42.6 %). Sub-area 8, located between sub-area 7E and 9 showed both strong wind and poor visibility. Typhoons, which occurred during research period, also interrupted the survey.

2. Species sighted

Table 2 summarizes the sightings made. Among the baleen whales, minke whale was the dominant species in all area researched by SSVs. A total of 134 schools (140 individuals) of minke whale was recorded by the SSVs, however, only 3 schools (3 individuals) were recorded by the SV (Fig.3). Most of the minke whale schools sighted were composed of a single animal and in only six cases schools were composed of two animals. Sei whale was the second dominant baleen whale species. Other baleen whales including blue, fin, humpback and right whale were also sighted by the SV or the SSVs in sub-area 9, but these species were rare in sub-areas 7E and 8 (Fig 4). In the large toothed whales, sperm whale was the dominant species (Fig.5) followed by unidentified ziphiid species in the all research area.

Of interest is the sighting by SV of a white killer whale. The animal was sighted at position 46° .9'N, 163° 19'E on 23 May 1997 within a school of about 15 individuals. Although the whole body was reported as white colored, researchers could not confirm whether it was a systemic albinism.

3. Sightings and sampling of minke whale

Table 3 shows density indices (DI; schools sighted / 100 n.miles searching distance) of minke whale by the SSVs in each sub-area. In the ordinary survey, the DI in sub-areas 9 and 8 were nearly the same but it was lower in sub-area 7E. Only two minke whales were sighted in sub-area 7E in spite of 688.1 n.miles of ordinary survey conducted and 586.6 n.miles as the SMS (Table 1). Higher DI was obtained in the SMS than ordinary survey. It was considered that the SMS was more effective to collect minke whale. However, the DI of both ordinary survey and the SMS in the BS mode were much lower than those in the BC mode, which reflect the difficulty of sighting in bad weather condition.

Fig. 6 shows the frequency distribution of sea surface water temperature where minke whale was sighted. Sightings of minke whales were concentrated in waters of surface temperature

range of 10℃ to 12℃. Sightings in sub-area 9 were frequent in the temperature range of 10-14℃, while those in sub-area 8 were frequent in the lower temperature range (8-12 ℃).

Out of 143 schools (149 individuals) of minke whales sighted by SSVs and a research base, 144 individuals were targeted for sampling. A total of 100 individuals was collected (67 from sub-area 9, 2 from sub-area 7E and 31 from sub-area 8) (Fig.7). Technical sampling efficiency (the rate of sampling for targeted individuals) was 0.69. Reasons for sampling failure are summarized in Table 4. The main reason was losing in sight of the targeted animal before chasing, in both BC and BS modes. This suggests that losing in sight of the minke whale was not only caused by bad weather condition but also caused in many cases by poor reaction to the vessel. When the targeted minke whale showed poor reaction to the vessel, it was very difficult to see the body of the whale continuously. It often resulted in sampling failure because it was hard to find blow of minke whale in the North Pacific waters.

4. Experiments

Sighting distance and angle experiment was performed at 2 July by the SSVs and 19 July by the SV.

Observation of behavior patterns of blue and fin whales was conducted by the SV. Only one trial for observation of a blue whale was successful at 28 June, because it was difficult to approach the whales without reaction to the vessel. During the observation time of 25 minutes, the animal made three times of diving. Ten to twelve blows were observed with time intervals from 7 to 47 seconds between each diving.

Photo-identification experiment was performed for ten individuals of three species by the SV and the SSVs (Table 5). Biopsy was also attempted in nineteen individuals of five species. One sample from a fin whale and another from a humpback whale were obtained. Although trials for sampling biopsy skin from minke whales were conducted on five individuals, in all these cases it was difficult to approach to an adequate range for shooting. Only one hit was obtained, but the sample was lost due to failure of the biopsy dart. The total time for the experiment was 172 minutes.

Satellite tagging experiment for minke whale was performed on two individuals on 10 July. A total of six shots was carried out but they missed and the experiment failed. The total time for the experiment was 162 minutes. Expansion of shooting range and lightening of the tag would be necessary in future.

XBT survey was conducted at 63 positions. Marine debris was found in the stomach of 24 minke whales of a total of 100 collected. Fragments of stone were the most frequent cases (11 cases) followed by plastics (nine cases). Most of debris were observed in the third (58.3%) or second (37.5%) compartment of the stomach.

5. Biological research

Biological data and samples were collected from 100 whales (87 males, 13 females). Table 6 summarizes the biological research items and number of animals examined. All samples and data related with the stock structure issue will be analyzed and reported in the near future.

6. Products

All the whales collected were processed on the NM after biological survey was completed, according to the provisions of Convention, Article VIII. A total of 298 tons of meat, blubber, viscera, etc. was produced. A total of 3.5 tons of oil was consumed as fuel for the ship.

7. Preliminary analyses of biological information

Sex ratio and reproductive status

Table 7 shows the reproductive status of all samples, by sub-area. Because histological examination has not done yet, maturity of male was tentatively determined by the testis weight according to Kato (1986), i. e., testis over than 400g was determined to mature and others were classified in immature. Mature males were dominant in all the research area, except in sub-area 7E where only two samples were collected. Most of all immature animals and pregnant females were obtained in sub-area 9 and more than half of females (5 immature, 2 pregnant) were collected in May.

Length composition

Table 8 shows mean body length of minke whale collected in each sub-area. Fig. 8 shows body length composition by sex and sub-area. Male animals collected in sub-area 9 showed bimodal distribution. There was no significant difference in mean body length of mature male between sub-area 9 and 8 (P=0.01).

Foetal length and conception date

Table 9 summarizes biological information of pregnant females and foetuses. The largest foetus was 40.8cm and the smallest was 1.2cm (CTL). Five out of six foetuses were collected in sub-area 9. Conception date of these foetuses were calculated to be late April to middle June according to the formulas used for southern minke whales (Kato and Miyashita, 1991). These conception date seem to be within the range of conception season of O-stock (Kato, 1992).

Prey species

Prey species was observed from stomach or other digestive tracts in 98 individuals. Frequencies of food species are summarized in Table 10. Although detailed species identification and quantitative analyses will be done in the near future, a preliminary analysis shows clear difference of dominant prey species between sub-areas. Japanese anchovy was the dominant species in sub-area 9, whereas Pacific saury was the dominant species in sub-area 8.

Organ abnormality

Abnormal organs were observed frequently in the minke whales sampled. Abnormality of testis or epididymes was highly observed in both sub-areas 9 (eight cases, 14.5% of males) and 8 (nine cases,30.0%). Abnormality of eyeball which was diagnosed visually as a scleral adhesion to palpebra was observed in six and two cases in sub-area 9 and 8, respectively. Gastric ulcer (seven cases), ulcer of the tongue (two cases), renal calculus (three cases) were also observed. These abnormal organs are rare in the southern minke whales sampled by the JARPA surveys and seem to be characteristics of the North Pacific minke whales (Fujise *et al.*, 1996, 1997).

Pathological examination of these abnormal organs with reference to the pollutant or parasites is now undergoing.

Parasites

Species and prevalence of parasites observed in the minke whales are summarized in Table 11. In the present survey, two animals which were the both *Anisakis* and *Bolbosoma* negative, and two which are *Anisakis* negative, were collected in sub-area 9 in May. Although immature animals shows low prevalence of parasites generally, the former two were immature female and the latter two were mature male and female. Areal differences in the prevalence of parasites will be investigated in terms of seasonal change or geographical variation.

DISCUSSION

One of the characteristics of the present research is that it was conducted in an early period (May and June). Previous JARPN surveys had been conducted in a late periods (from late June to September). It was expected to collect information of distribution and biology on minke whales in the earlier period.

Distribution of minke whales in sub-area 9 was lower than that of previous surveys in the same area (Fujise *et al.*, 1996). Although it appears that the DI under BC mode in previous survey was lower than the present survey except for July (second period in 1995; 1.45), track-lines of SSVs in the present survey was limited to waters where high density of minke whales were expected. The SV, which surveyed the entire sub-area 9, sighted only one minke whale in spite of 2581.3 n.miles of survey (DI = 0.0004). Distribution of minke whales in the early period seems to concentrate in small areas, probably related with food availability.

It is noteworthy that many unidentified whales were recorded by the SSVs. According to description in the sighting records, many of these whales seem to be minke whales or ziphiid whales. Ziphiid whales are known to be difficult to re-sight after deep diving, and bad weather condition also causes fault of species identification in many cases. Unlike the Antarctic Ocean, it is difficult to detect the blow of minke whales in the North Pacific (Fujise *et al.*, 1995, 1996). Furthermore, it should be considered that the reaction of the minke whale in the North Pacific to the vessel is often weak comparing to that in the Antarctic Ocean. Such a difference of behavior might be caused by the difference of traffic volume of ships between North Pacific and Antarctic Ocean (or South Pacific). There is a possibility that the poor reaction for the vessel is one of the reason for many unidentified whales.

Only two minke whales were sighted in sub-area 7E in spite of the fact that the searching effort was concentrated in the water where the surface temperature was around 12℃. Similar result of sightings was obtained in the previous JARPN survey (Fujise *et al.*, 1997). Although it is unclear whether the food of minke whales was available in this area, there is a possibility that minke whales tend to migrate to coastal waters of Japan such as sub-area 7W where food availability is expected to be higher.

Sightings of minke whales were limited to small zones where surface water temperature were 10℃-14℃ in sub-area 9 and 8℃-12℃ in sub-area 8 (Fig.6). It is interesting to note that the

water temperature of minke whale abundant area in sub-area 8 recorded in July is lower than that in sub-area 9 in May-June. It was observed that the water temperature in which minke whales were frequently sighted increased seasonally in the previous survey (Fujise *et al.*, 1996). The most plausible explanation is the change of prey species in different sub-areas . Unlike the previous survey, the main prey species of minke whale in sub-area 9 was Japanese anchovy. Pacific saury which was said to be main prey species of minke whale in sub-area 9 (Fujise *et al.*, 1996) was dominant only in sub-area 8 in 1997. Fig. 9 shows relationship among surface water temperature, body length of minke whale and prey species. Japanese anchovies were detected at the temperature over 11℃, whereas most of Pacific sauries were detected under 12℃. This tendency coincides with the sighting frequency of minke whales by surface water temperature of sub-areas. As favorable water temperature for Pacific saury is lower than that for anchovy (JFRCH, 1980), minke whale might tend to concentrate in lower temperature waters of sub-area 8. Whether minke whales prefer Pacific saury to anchovy is not clear, it appears that minke whales change food species from anchovy to Pacific saury with the advance of the season, because previous surveys conducted in sub-area 7, 8 and 9 in late season showed dominant frequency of Pacific saury as prey food species (Fujise *et al.*, 1997). Euphausiids were observed in stomachs of six individuals. Three of them were immature. It seems that larger (male) animals tend to eat larger prey species such as Pacific sauries, however, it should be also noted that there were few immature animals in the waters where Pacific sauries dominated (sub-area 8).

Reproductive status observed in early May in sub-area 9 is important. It suggested that immature and female minke whale migrate into or pass through sub-area 9 prior to mature males, which are dominant in mid summer. Further information would be needed in the early season of sub-area 9 to reveal such a hypothesis. However, it should be noted that collection of enough sample in the early season could be difficult because of low density of minke whale and bad weather.

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Table 1a. Searching distances and sightings of minke whales (schools/individuals) by three sighting/ sampling vessels by different searching mode and survey type in each sub-area. Number with asterisk include minke whales sighted by research base *Nissin Maru*.

Sub-area 9

	Ordinary Survey			Special Monitoring Survey		
Searching Mode	Searching Distance	Primary Sighting	Secondary Sighting	Searching Distance	Primary Sighting	Secondary Sighting
BC	3731.2	30/32	6/6	1124.0	21/22	0/0
BS	1968.0	6/6	2/2	1435.2	3/4	1/1
OE	-	-	8/8*	-	-	15/15*
Total	5699.2	36/38	16/16*	2559.2	24/26	16/16*

Sub-area 7E

	Ordinary Survey			Special Monitoring Survey		
Searching Mode	Searching Distance	Primary Sighting	Secondary Sighting	Searching Distance	Primary Sighting	Secondary Sighting
BC	502.7	1/1	0/0	384.6	1/1	0/0
BS	186.1	0/0	0/0	202.0	0/0	0/0
OE	-	-	0/0	-	-	0/0
Total	688.8	1/1	0/0	586.6	1/1	0/0

Sub-area 8

	Ordinary Survey			Special Monitoring Survey		
Searching Mode	Searching Distance	Primary Sighting	Secondary Sighting	Searching Distance	Primary Sighting	Secondary Sighting
BC	622.7	6/7	0/0	841.0	12/13	1/1
BS	570.9	0/0	0/0	587.1	6/6	1/1
OE	-	-	6/6*	-	-	17/17*
Total	1193.6	6/7	6/6*	1428.1	18/19	19/19*

Table 1b. Searching distances and sightings of minke whales (schools/individuals) by sighting vessel *Kyoshin Maru No. 2* in each sub-area. Sighting vessel did not apply special monitoring survey and BS mode.

Research Area	Searching Mode	Searching Distance	Primary Sighting	Secondary Sighting
Sub-area 9	BC	2581.3	1/1	0/0
	OE	-	-	0/0
Sub-area 8	BC	326.3	2/2	0/0
	OE	-	-	0/0
Total		2907.6	3/3	0/0

Table 2a. Summary of sightings (no. schools /.no. individuals) conducted by three sighting / sampling vessels in sub-area 9.

Species	Searching mode						
	BC mode		BS mode		OE mode	Total	
	Primary	Secondary	Primary	Secondary	Secondary	Primary	Secondary
Minke whale	51/54	6/6	9/10	3/3	19/19	60/64	28/28*
Like minke whale	5/5	1/1	4/4	0/0	4/4	9/9	5/5**
Blue whale	2/2	0/0	1/1	1/1	0/0	3/3	1/1
Fin whale	7/9	0/0	0/0	0/0	1/3	7/9	1/3
Sei whale	9/9	1/2	10/15	1/1	4/5	19/24	6/8
Humpback whale	1/2	0/0	2/3	0/0	0/0	3/5	0/0
Sperm whale	70/93	4/5	6/6	1/1	9/10	76/99	14/16
Killer whale	6/39	1/2	5/24	0/0	1/2	11/63	2/4
Stejnegeri's beaked whale	1/2	0/0	0/0	0/0	0/0	1/2	0/0
Unidentified Mesoplodon	1/4	0/0	2/2	0/0	0/0	3/6	0/0
Unidentified Ziphiidae	33/51	0/0	14/19	0/0	1/1	47/70	1/1
Dall's porpoise	92/774	1/2	48/299	0/0	17/103	140/1073	18/105
dalli type	48/339	1/2	34/229	0/0	14/81	82/568	15/83
Black type	0/0	0/0	1/1	0/0	0/0	1/1	0/0
Type unidentified	44/435	0/0	13/69	0/0	3/22	57/504	3/22
Pacific white-sided dolphin	0/0	0/0	7/74	1/3	0/0	7/74	1/3
Northern right whale dolphin	0/0	0/0	1/4	0/0	0/0	1/4	0/0
Common dolphin	3/145	0/0	3/22	0/0	0/0	6/167	0/0
Short-finned pilot whale	0/0	0/0	1/3	0/0	0/0	1/3	0/0
Risso's dolphin	1/10	0/0	0/0	0/0	0/0	1/10	0/0
Unidentified pilot whales	0/0	0/0	2/13	0/0	1/1	2/13	1/1
Unidentified large cetacean	3/3	1/1	5/6	1/1	3/3	8/9	5/5
Unidentified small cetacean	0/0	0/0	1/1	0/0	0/0	1/1	0/0
Unidentified dolphin	144/1507	5/60	35/226	1/3	9/59	179/1733	15/122
Unidentified cetacean	38/39	1/1	30/30	0/0	5/5	68/69	6/6

*: excluding 4 sightings (4 individuals) by the research base.

**: excluding 2 sightings (2 individuals) by the research base.

Table 2b. Summary of sightings (no. schools / no. individuals) conducted by three sighting / sampling vessels in sub-area 7E.

Species	Searching mode						
	BC mode		BS mode		OE mode	Total	
	Primary	Secondary	Primary	Secondary	Secondary	Primary	Secondary
Minke whale	2/2	0/0	0/0	0/0	0/0	2/2	0/0
Fin whale	1/1	0/0	0/0	0/0	0/0	1/1	0/0
Humpback whale	0/0	0/0	0/0	0/0	1/1	0/0	1/1
Sperm whale	6/13	6/9	0/0	0/0	0/0	6/13	6/9
Killer whale	9/33	0/0	1/3	0/0	0/0	10/36	0/0
Unidentified Mesoplodon	1/1	0/0	0/0	0/0	0/0	1/1	0/0
Unidentified Ziphiidae	29/52	1/1	4/6	0/0	1/1	33/58	2/2
Dall's porpoise	15/74	0/0	4/29	0/0	3/18	19/103	3/18
dalli type	4/13	0/0	2/8	0/0	1/3	6/21	1/3
truei type	4/22	0/0	0/0	0/0	2/15	4/22	2/15
Type unidentified	7/39	0/0	2/21	0/0	0/0	9/60	0/0
Pacific white-sided dolphin	13/395	1/30	15/184	0/0	4/37	28/579	5/67
Northern right whale dolphin	0/0	0/0	0/0	0/0	1/10	0/0	1/10
Risso's dolphin	0/0	0/0	1/13	0/0	0/0	1/13	0/0
Unidentified pilot whales	1/5	0/0	0/0	0/0	0/0	1/5	0/0
Unidentified large cetacean	1/1	0/0	0/0	0/0	0/0	1/1	0/0
Unidentified dolphin	21/719	0/0	5/83	0/0	1/5	26/802	1/5
Unidentified cetacean	8/8	0/0	1/1	0/0	0/0	9/9	0/0

Table 2c. Summary of sightings (no. schools / no. individuals) conducted by three sighting / sampling vessels in sub-area 8.

Species	Searching mode						
	BC mode		BS mode		OE mode	Total	
	Primary	Secondary	Primary	Secondary	Secondary	Primary	Secondary
Minke whale	18/20	1/1	6/6	1/1	18/18	24/26	20/20*
Like minke whale	1/1	0/0	0/0	0/0	1/1	1/1	1/1
Sperm whale	42/64	1/1	18/20	0/0	3/21	60/84	4/22
Killer whale	8/35	0/0	0/0	0/0	5/14	8/35	5/14
Unidentified Mesoplodon	1/2	0/0	0/0	0/0	0/0	1/2	0/0
Unidentified Ziphiidae	16/30	0/0	6/9	1/2	1/2	22/39	2/4
Dall's porpoise	26/145	1/15	13/79	0/0	19/85	39/224	20/100
dalli type	15/77	0/0	12/75	0/0	15/66	27/152	15/66
Black type	0/0	0/0	0/0	0/0	1/1	0/0	1/1
Type unidentified	11/68	1/15	1/4	0/0	3/18	12/72	4/33
Pacific white-sided dolphin	0/0	0/0	3/25	0/0	3/22	3/25	3/22
Unidentified large cetacean	0/0	0/0	2/2	0/0	0/0	2/2	0/0
Unidentified dolphin	19/119	1/5	9/63	0/0	1/4	28/182	2/9
Unidentified cetacean	13/13	1/1	6/6	0/0	1/1	19/19	2/2

*: excluding 5 sightings (5 individuals) by the research base.

Table 2d. Summary of sightings (no. schools / no. individuals) conducted by three sighting / sampling vessels in all area.

Species	Searching mode						
	BC mode		BS mode		OE mode	Total	
	Primary	Secondary	Primary	Secondary	Secondary	Primary	Secondary
Minke whale	71/76	7/7	15/16	4/4	37/37	86/92	48/48*
Like minke whale	6/6	1/1	4/4	0/0	5/5	10/10	6/6**
Blue whale	2/2	0/0	1/1	1/1	0/0	3/3	1/1
Fin whale	8/10	0/0	0/0	0/0	1/3	8/10	1/3
Sei whale	9/9	1/2	10/15	1/1	4/5	19/24	6/8
Humpback whale	1/2	0/0	2/3	0/0	1/1	3/5	1/1
Sperm whale	118/170	11/15	24/26	1/1	12/31	142/196	24/47
Killer whale	23/107	1/2	6/27	0/0	6/16	29/134	7/18
Stejnegeri's beaked whale	1/2	0/0	0/0	0/0	0/0	1/2	0/0
Unidentified Mesoplodon	3/7	0/0	2/2	0/0	0/0	5/9	0/0
Unidentified Ziphiidae	78/133	1/1	24/34	1/2	3/4	102/167	5/7
Dall's porpoise	133/993	2/17	65/407	0/0	39/206	198/1400	41/223
dalli type	67/429	1/2	48/312	0/0	30/150	115/741	31/152
truei type	4/22	0/0	0/0	0/0	2/15	4/22	2/15
Black type	0/0	0/0	1/1	0/0	1/1	1/1	1/1
Type unidentified	62/542	1/15	16/94	0/0	6/40	78/636	7/55
Pacific white-sided dolphin	13/395	1/30	25/283	1/3	7/59	38/678	9/92
Northern right whale dolphin	0/0	0/0	1/4	0/0	1/10	1/4	1/10
Common dolphin	3/145	0/0	3/22	0/0	0/0	6/167	0/0
Short-finned pilot whale	0/0	0/0	1/3	0/0	0/0	1/3	0/0
Risso's dolphin	1/10	0/0	1/13	0/0	0/0	2/23	0/0
Unidentified pilot whales	1/5	0/0	2/13	0/0	1/1	3/18	1/1
Unidentified large cetacean	4/4	1/1	7/8	1/1	3/3	11/12	5/5
Unidentified small cetacean	0/0	0/0	1/1	0/0	0/0	1/1	0/0
Unidentified dolphin	184/2345	6/65	49/372	1/3	11/68	233/2717	18/136
Unidentified cetacean	59/60	2/2	37/37	0/0	6/6	96/97	8/8

*: excluding 9 sightings (9 individuals) by the research base.

**: excluding 2 sightings (2 individuals) by the research base.

Table 2e. Summary of sightings (no. schools / no. individuals) conducted by sighting vessel, *Kyoshin Maru No. 2* in the research area.

	Research area					
	Sub-area 9		Sub-area 8		Total	
Species	Primary	Secondary	Primary	Secondary	Primary	Secondary
Minke whale	1/1	0/0	2/2	0/0	3/3	0/0
Like minke whale	2/2	0/0	1/1	0/0	3/3	0/0
Blue whale	2/2	0/0	0/0	0/0	2/2	0/0
Fin whale	3/6	0/0	0/0	0/0	3/6	0/0
Sei whale	29/62	2/3	0/0	0/0	29/62	2/3
Bryde's whale	1/1	0/0	0/0	0/0	1/1	0/0
Humpback whale	2/2	0/0	0/0	0/0	2/2	0/0
Right whale	1/1	1/2	0/0	0/0	1/1	1/2
Sperm whale	18/19	1/1	7/7	1/1	25/26	2/2
Killer whale	3/9	1/15	0/0	1/1	3/9	2/16
Cuvier's beaked whale	0/0	0/0	1/2	0/0	1/2	0/0
Unidentified Mesoplodon	1/2	0/0	0/0	0/0	1/2	0/0
Unidentified Ziphiidae	12/26	0/0	2/4	1/3	14/30	1/3
Dall's porpoise	65/297	13/84	15/39	0/0	80/336	13/84
dalli type	22/115	8/48	6/18	0/0	28/133	8/48
truei type	1/4	0/0	0/0	0/0	1/4	0/0
Type unidentified	42/178	5/36	9/21	0/0	51/199	5/36
Pacific white-sided dolphin	6/46	7/140	3/370	1/4	9/416	8/144
Northern right whale dolphin	1/45	2/165	2/65	1/10	3/110	3/175
Common dolphin	12/172	0/0	0/0	0/0	12/172	0/0
Risso's dolphin	0/0	1/6	0/0	0/0	0/0	1/6
Unidentified large cetacean	6/7	8/11	0/0	0/0	6/7	8/11
Unidentified small cetacean	4/7	0/0	0/0	0/0	4/7	0/0
Unidentified dolphin	59/380	6/45	12/74	1/2	71/454	7/47
Unidentified cetacean	4/7	1/2	4/8	0/0	8/15	1/2

Table 3. Density indices (DI; schools sighted / 100n. miles sighting distance) of minke whale in each sub-area which were conducted by the three SSVs, excluding SV and NM.

Sub-area 9

	Ordinary Survey		Special Monitoring Survey	
Mode	Primary sighting	Primary+Secondary sighting	Primary sighting	Primary+Secondary sighting
BC	0.80	0.96	1.87	1.87
BS	0.30	0.41	0.21	0.28
Total	0.63	0.91	0.94	1.56

Sub-area 7E

	Ordinary Survey		Special Monitoring Survey	
Mode	Primary sighting	Primary+Secondary sighting	Primary sighting	Primary+Secondary sighting
BC	0.20	0.20	0.26	0.26
BS	0.00	0.00	0.00	0.00
Total	0.15	0.15	0.17	0.17

Sub-area 8

	Ordinary Survey		Special Monitoring Survey	
Mode	Primary sighting	Primary+Secondary sighting	Primary sighting	Primary+Secondary sighting
BC	0.96	0.96	1.43	1.55
BS	0.00	0.00	1.02	1.19
Total	0.50	0.92	1.26	2.31

Table 4. Causes of sampling failure by searching mode. A; long diving, B; quick motion, C; rough sea condition, D; technical problems, E; missing of the targeted animal before chasing, F; others (sun set, border of research area etc.).

	Reasons for sampling failure						
Mode	*A*	*B*	*C*	*D*	*E*	*F*	Total
BC Primary	1	2	0	1	8	1	13
BC Secondary	1	0	0	0	2	1	4
BS Primary	1	1	0	0	3	0	5
BS Secondary	0	1	0	0	2	0	3
OE Secondary	0	1	4	2	9	3	19
Total	3	5	4	3	24	5	44

Table 5. Summary of the results of photo-ID and biopsy experiment. Fin and minke whales were not targeted for photo-ID experiment. "N.T." represents no trial.

Date	Position	Species	School Size	Individual No.	Photograph Target Region	Photo. Result	Biopsy Result
970508	37.02 N 160.37 E	Fin whale	1	1	-	N.T.	Success
970512	39.35 N 164.33 E	Blue whale	1	1	Lateral side (R)	Good	Fault
970512	40.14 N 165.56 E	Blue whale	1	1	Dorsal fin (L)	Good	~~Fault~~
970515	51.06 N 166.08 E	Right whale	1	1	Head, tail flukes	Excellent	Fault
970516	50.04 N 163.11 E	Humpback whale	1	1	Head, tail flukes	Good	Fault
970516	49.52 N 163.03 E	Fin whale	3	1	-	N.T.	Fault
970519	47.31 N 169.49 E	Fin whale	2	1	-	N.T.	Fault
970527	37.50 N 163.20 E	Humpback whale	1	1	Lateral side (LR)	Good	Fault
					Dorsal fin (L)	Good	
970604	41.10 N 161.25 E	Fin whale			-	N.T.	Fault
970605	40.15 N 161.12 E	Humpback whale	2	1	Lateral side (LR)	Excellent	Success
					Dorsal fin (L)	Excellent	
					Head	Excellent	
				2	Lateral side (L)	Excellent	Fault
					Dorsal fin (L)	Excellent	
					Head	Excellent	
970621	36.27 N 164.03 E	Blue whale	1	1	Dorsal fin, head	Good	Fault
970625	38.01 N 168.17 E	Humpback whale	1	1	Dorsal fin (LR)	Poor	Fault
970628	39.26 N 161.25 E	Minke whale	1	1	-	N.T.	Fault
970628	39.34 N 160.47 E	Blue whale	1	1	Lateral side (R)	Good	Fault
970706	42.13 N 153.03 E	Minke whale	1	1	-	N.T.	Fault
970707	40.08 N 151.32 E	Minke whale	1	1	-	N.T.	Fault
970710	41.56 N 154.05 E	Minke whale	1	1	-	N.T.	Fault
970711	41.52 N 154.17 E	Minke whale	1	1	-	N.T.	Fault

Table. 6. Summary of biological data and samples collected. Number with parenthesis represents foetal sample.

Samples and data	Number of whales		
	Male	Female	Total
Body length and sex	87	13	100
External body proportion	87	13	100
Photographic record and external character	87	13	100
Diatom film record and sampling	87	13	100
Standard measurements of blubber thickness (eleven points)	87	13	100
Detailed measurements of blubber thickness	25	6	31
Body weight	87	13	100
Body weight by parts	25	6	31
Blubber, muscle, liver and heart tissues for DNA study	87	13	100
Muscle, liver and heart tissues for isozyme analysis	87	13	100
Muscle, liver and kidney tissues for heavy metal analysis	87	13	100
Tissues for organochlorine analysis	87	13	100
Tissues for lipid analysis	25	6	31
Mammary grand; lactation status, measurement and histological sample	-	13	13
Ovary collection	-	13	13
Uterine horn; measurement and endometrium sample	-	13	13
Uterine mucus for sperm detection	-	13	13
Photographic record of foetus	(4)	(1)	(6)
Foetal length and weight	(4)	(1)	(6)
External measurements of foetus	(4)	(1)	(5)
Collection of foetus	(0)	(0)	(1)
Testis and epididymis; weight and histological sample	87	-	87
Smear samples from testis and epididymis tissues	87	-	87
Urine sample for sperm detection	73	-	73
Serum sample for physiological study	87	13	100
Stomach content, conventional record	87	13	100
Weight of stomach content in each compartment	87	13	100
Collection of stomach contents for food and feeding study	87	13	100
Collection of stomach contents for organochlorine analysis	36	2	38
Collection of stomach contents for heavy metal analysis	36	2	38
Collection of stomach contents for lipid analysis	6	0	6
Collection of external parasites	29	4	33
Collection of parasites from 1st stomach	9	0	9
Collection of parasites from 2nd stomach	40	3	43
Collection of parasites from 3rd stomach	19	1	20
Collection of parasites from 4th stomach	14	1	15
Collection of parasites from intestine	26	3	29
Collection of parasites from liver	58	2	60
Feces for parasite egg examination	87	13	100
Earplug for age determination	87	13	100
Tympanic bulla for age determination	85	12	97
Largest baleen plate	87	13	100
Vertebral epiphyses sample	87	13	100
Skull measurement(length and breadth)	84	12	96
Collection of skull	2	1	3
Jaws for morphological study	1	0	1
Jaws of foetus for embryological study	4	0	0

Table 7. Reproductive status of minke whales collected. Maturity of males was tentatively defined by testis weight according to Kato (1986) i.e., testis over than 400g was determined to mature and others were classified in immature..

Sub-area	Male		Female		Total
	Immature	Mature	Immature	Mature (pregnant)	
9	14 (20.9%)	41 (61.2%)	7 (10.4%)	5 (7.5%)	67 (100%)
7 E	1 (50.0%)	1 (50.0%)	0	0	2 (100%)
8	1 (3.2%)	29 (93.5%)	0	1 (3.2%)	31 (100%)
Total	16 (16.0%)	71 (71.0%)	7 (7.0%)	6 (6.0%)	100 (100%)

Table 8. Mean body length (m) with standard deviation and body length range of minke whales collected in each area. Maturity of males was defined as Table 7.

Sub-area	Male		Female	
	Immature	Mature	Immature	Mature (pregnant)
9	6.24±0.45	7.42±0.31	5.62±1.03	7.58±0.35
	(5.58-7.57)	(6.58-7.97)	(4.36-7.25)	(6.97-8.00)
7 E	4.78	7.53	-	-
	(4.78)	(7.53)		
8	6.51	7.47±0.36	-	7.75
	(6.51)	(6.68-8.22)		(7.75)
Total	6.17±0.55	7.44±0.33	5.62±1.03	7.61±0.32
	(4.78-7.57)	(6.58-8.22)	(4.36-7.25)	(6.97-8.00)

Table 9. Summary of biological information of pregnant females and foetuses collected in the 1997 JARPN surveys. CTL (crown-tail length) represents strait length between crown and tail bend.

Sampling date	Area	Body length (m)	Blubber thickness (cm)	Foetal length (cm)	Foetal sex
8 May	9	6.97	3.0	1.2 (CTL)	Unknown
30 May	9	7.61	4.0	26.4	Male
1 June	9	7.50	3.9	40.8	Male
6 June	9	7.80	2.4	30.6	Male
11 June	9	8.00	4.0	21.0	Female
8 July	8	7.75	3.6	18.6	Male

Table 10. Prey species of minke whales and the total frequency of occurrence by area. Number with parenthesis represents the number of minke whales whose stomachs were occupied by single food species.

Prey species	Sub-area 9	Sub-area 7E	Sub-area 8
Japanese anchovy	60 (56)	1 (0)	2 (1)
Pacific saury	4 (3)	0	30 (23)
Salmon	0	0	2 (0)
Sardine?	0	0	1 (0)
Squids	0	0	5 (0)
Euphausiids	6 (3)	2 (1)	0

Table 11a. Parasitological examinations on minke whales

Habitats	Parasites
Skin	*Pennella*
	Whale louse (*Cyamus*)
	Chonchoderma on *Pennella*
	Barnacles
Blubber	Not detected
Cranial sinus	Not detected
Baleen plates	Not detected
Larynx	Not detected
Esophagus	Not detected
Lung	Not detected
Stomachs	Nematodes (*Anisakis*)
Liver	Trematodes (*Lechithodesmus*)
Pancreas	Not detected
Kidney	Not detected
Small intestine	Cestodes (*Diplogonoporus* and others)
	Larval Cestodes
	Acanthocephala (*Bolbosoma* spp.)
Large intestine	Not detected
Appendix	Not detected

Table 11b. Prevalences of the parasites in minke whales collected in each area.

A; No. of parasite positive whales/ No. of whales examined.

B; prevalences (%)

Habitats	Species	Sub-area 9		Sub-area 7 E		Sub-area 8		Total	
		A	B	A	B	A	B	A	B
Skin	*Pennella*	46/67	68.7	2/2	100	20/31	64.5	68/100	68.0
	Cyamus	1/67	1.5	0/2	0	0/31	0	1/100	1.0
	Chonchoderma	5/67	7.5	0/2	0	1/31	3.2	6/100	6.0
	Barnacles	4/67	6.0	0/2	0	5/31	16.1	9/100	9.0
Stomachs									
1st	*Anisakis*	35/63	55.6	0/2	0	20/30	66.7	55/95	57.9
2nd	*Anisakis*	63/66	95.5	2/2	100	30/31	96.8	95/99	96.0
3rd	*Anisakis*	42/62	67.7	2/2	100	30/30	100	74/94	78.7
4th	*Anisakis*	25/65	38.5	0/2	0	20/30	66.7	45/97	46.4
Liver	*Lecithodesmus*	32/67	47.8	1/2	50.0	21/31	67.7	54/100	54.0
Intestine	*Bolbosoma*	64/66	97.0	2/2	100	29/29	100	95/97	97.9
	Cestodes	15/65	23.1	1/2	50.0	5/28	17.9	21/95	22.1
	Larval cestodes	2/5	40.0	1/1	100	2/6	33.3	5/12	41.7

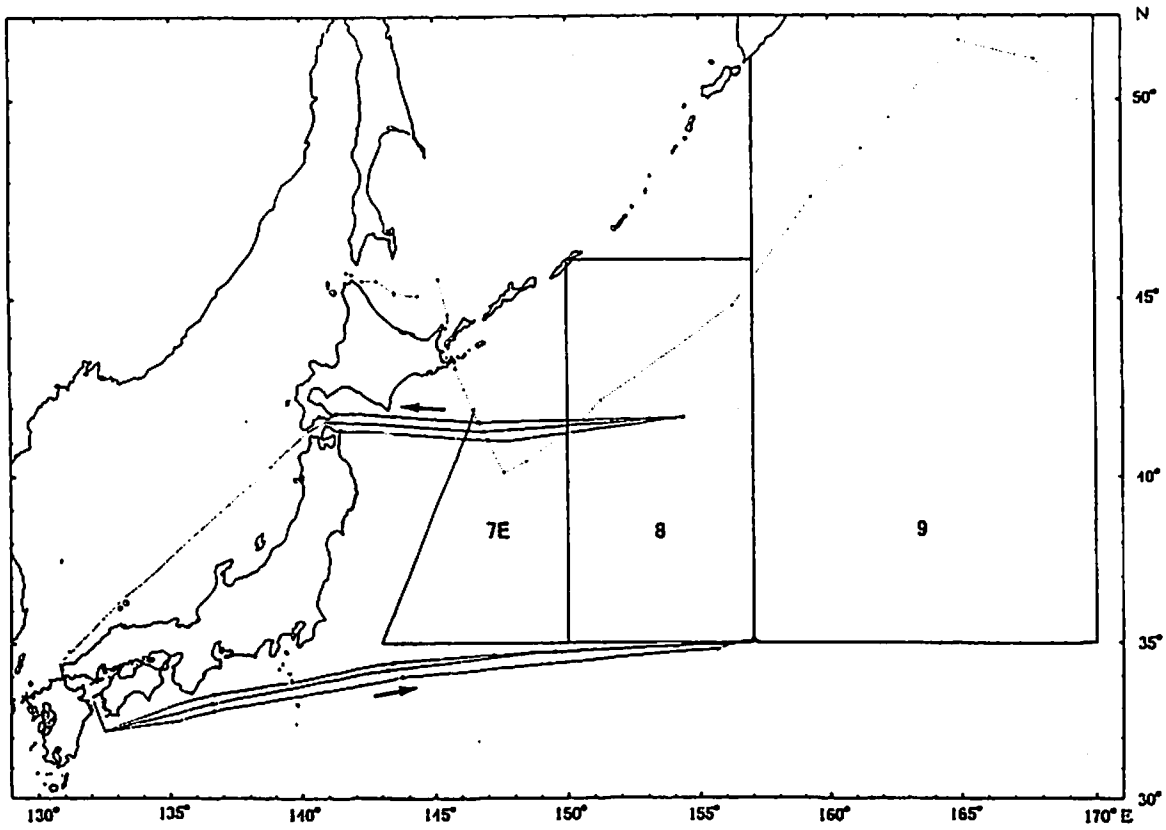

Fig. 1. Geographic location of research area of the 1997 JARPN surveys and cruise tracks of sighting survey between research area and Japan.

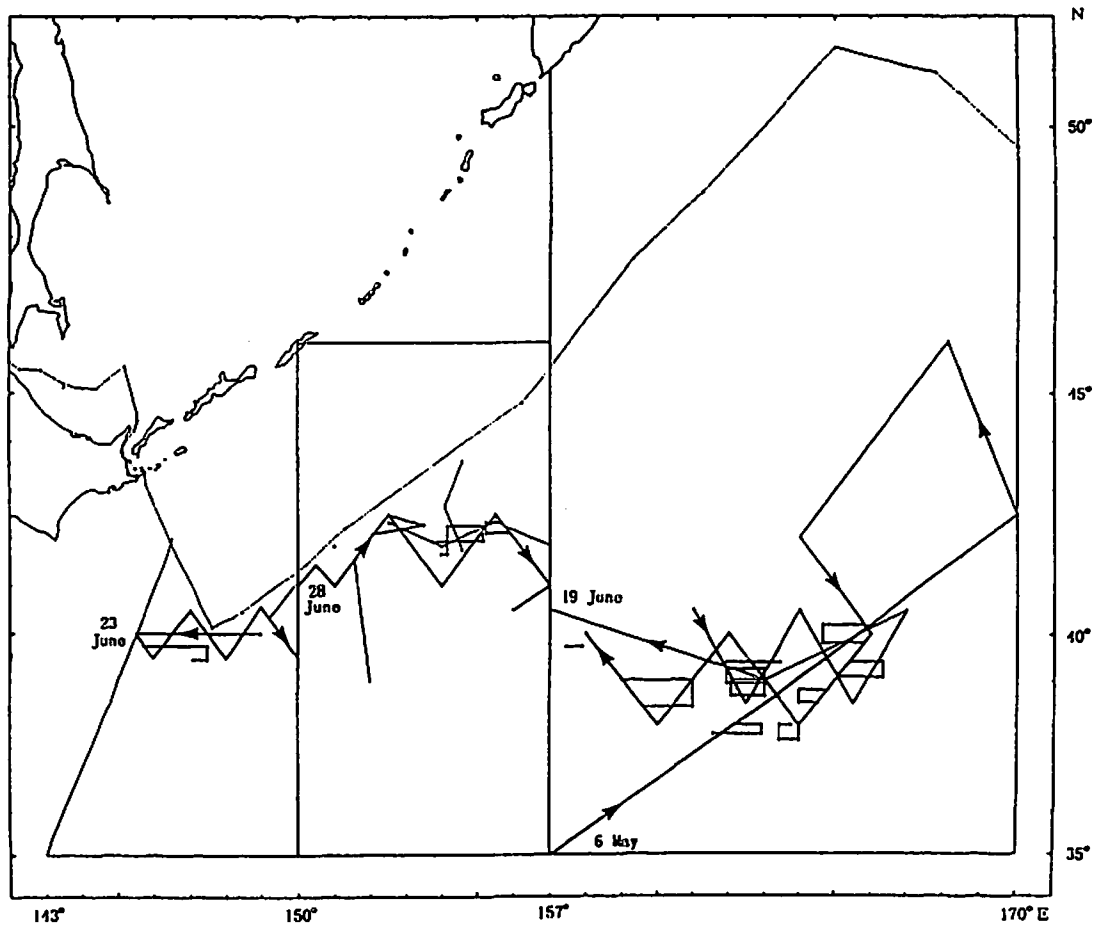

Fig. 2a. Cruise track line of sighting/ sampling vessels of JARPN in 1997. Thick line represents main survey and thin line represents Special Monitoring Survey.

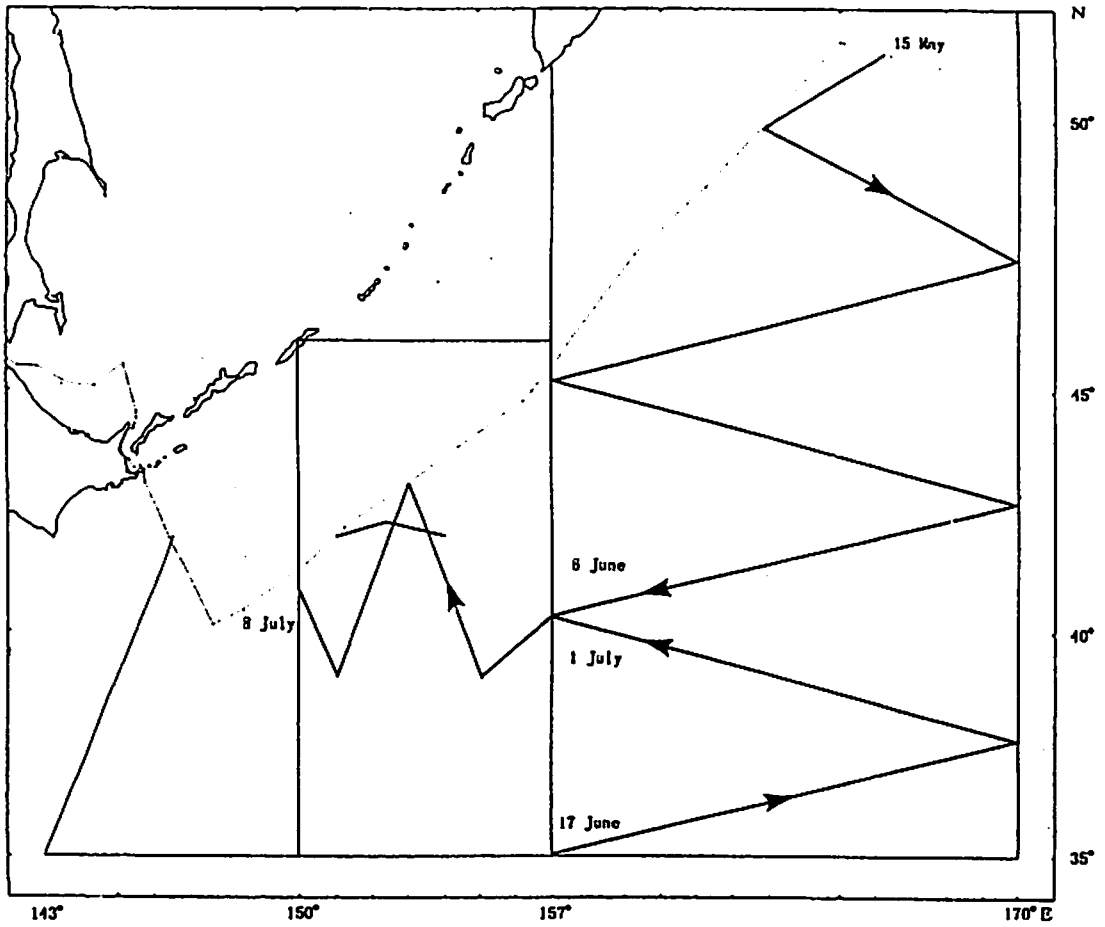

Fig. 2b. Cruise track line of a dedicated sighting vessel of JARPN in 1997.

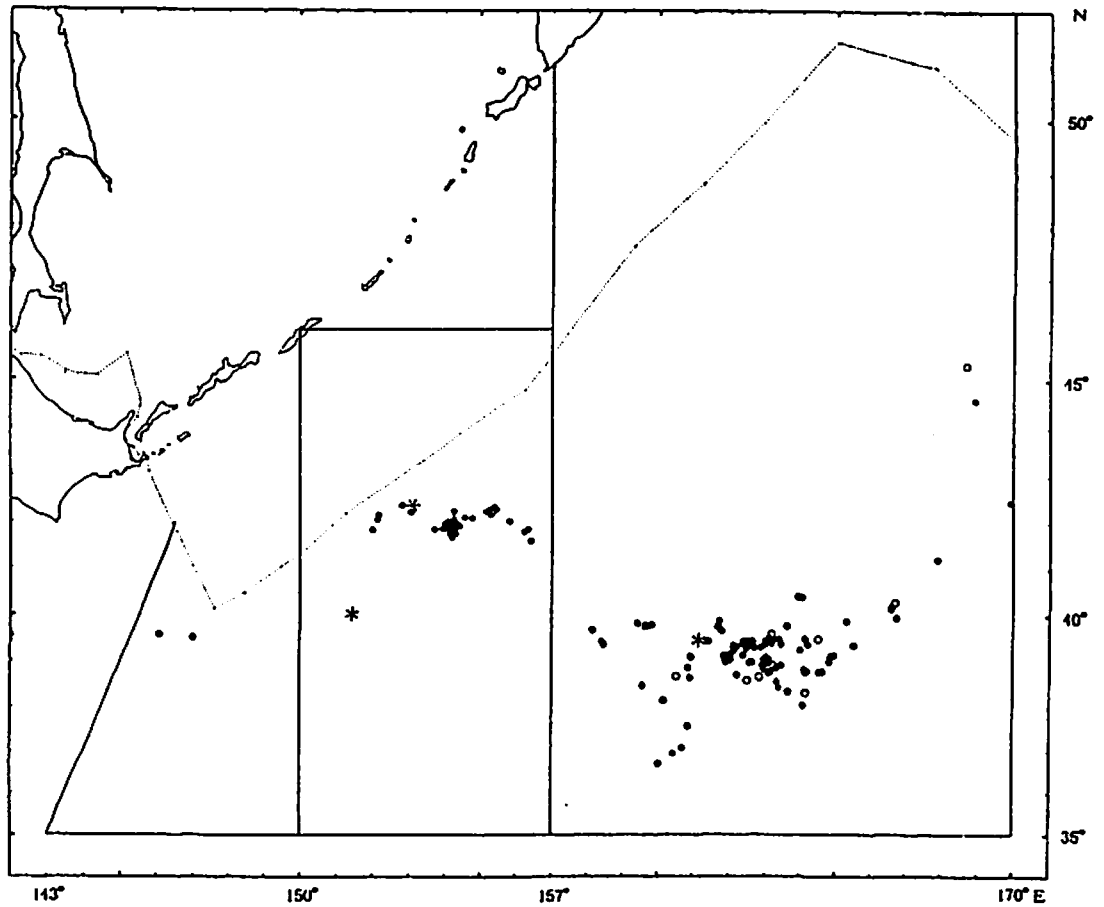

Fig. 3. Distribution of the sighting of minke whale (closed circle) and like minke whale (open circle). Asterisks represent sightings of a dedicated sighting vessel.

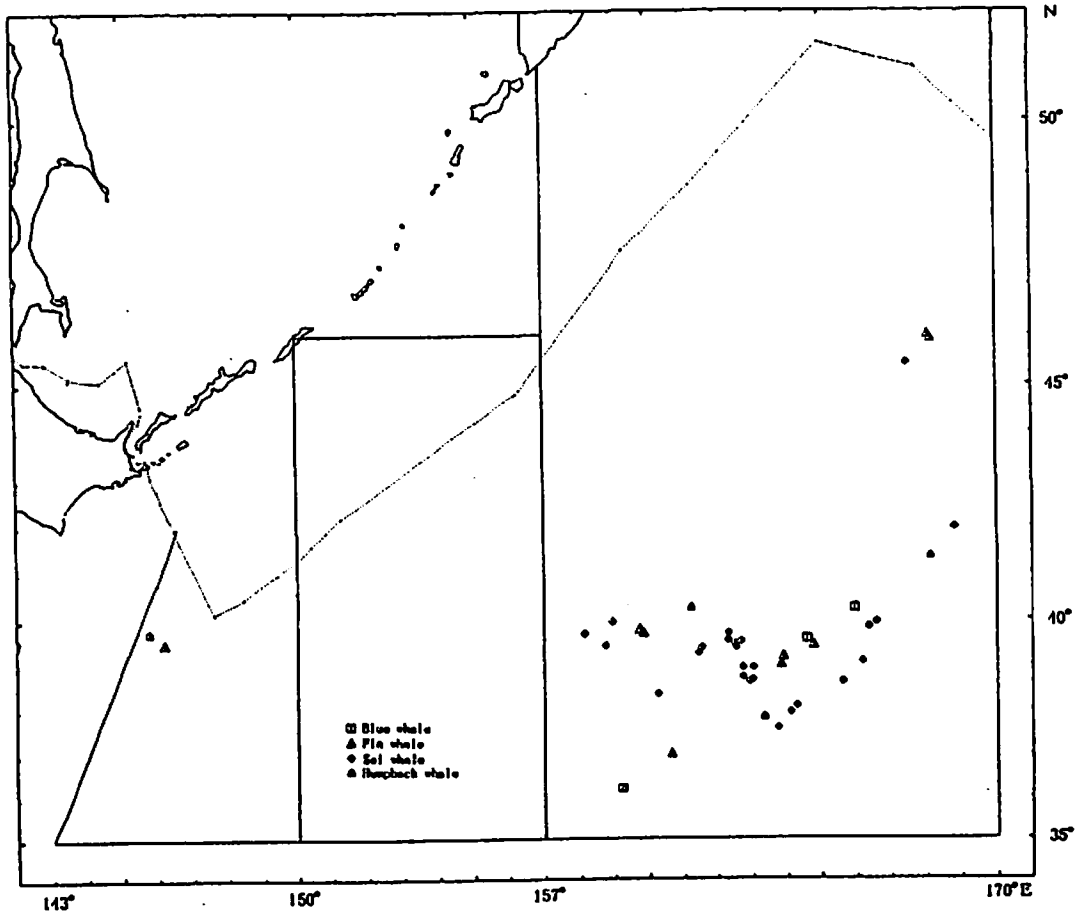

Fig. 4. Distribution of blue, fin, sei, humpback and right whales sighted by three sighting/ sampling vessels.

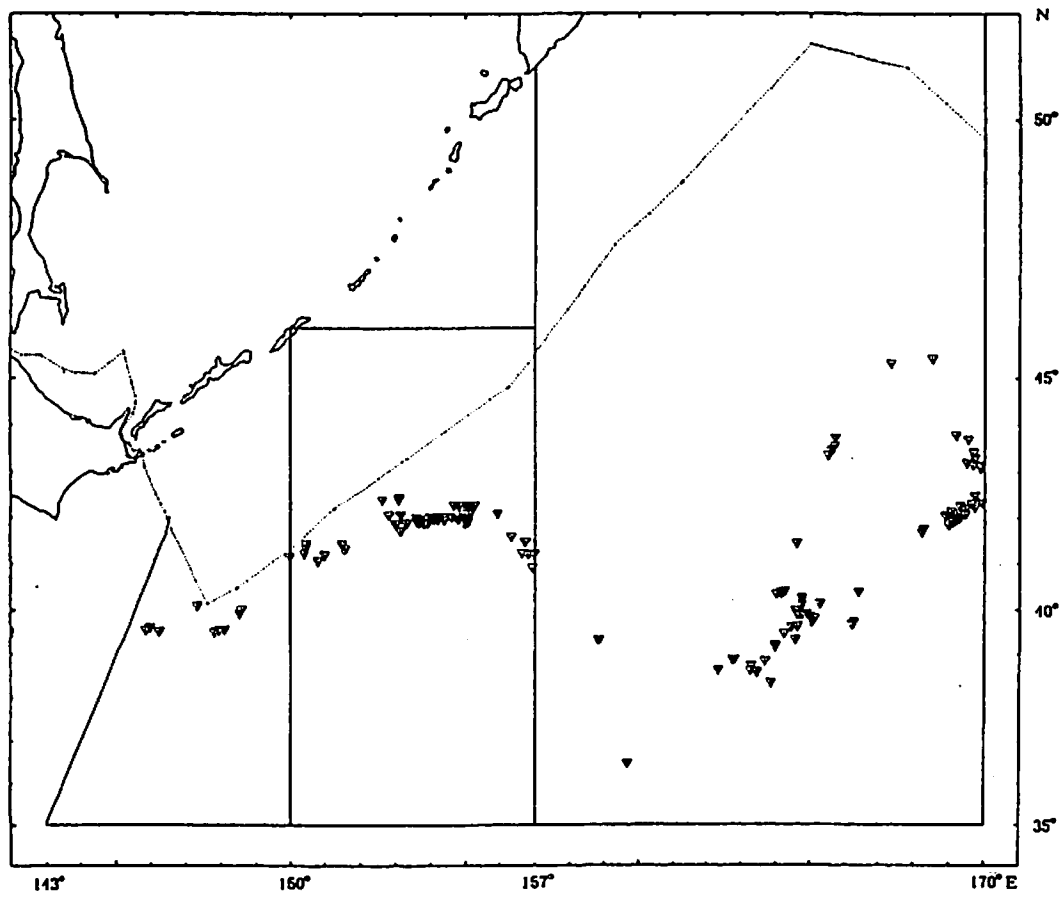

Fig. 5. Distribution of sperm whales sighted by three sighting/ sampling vessels.

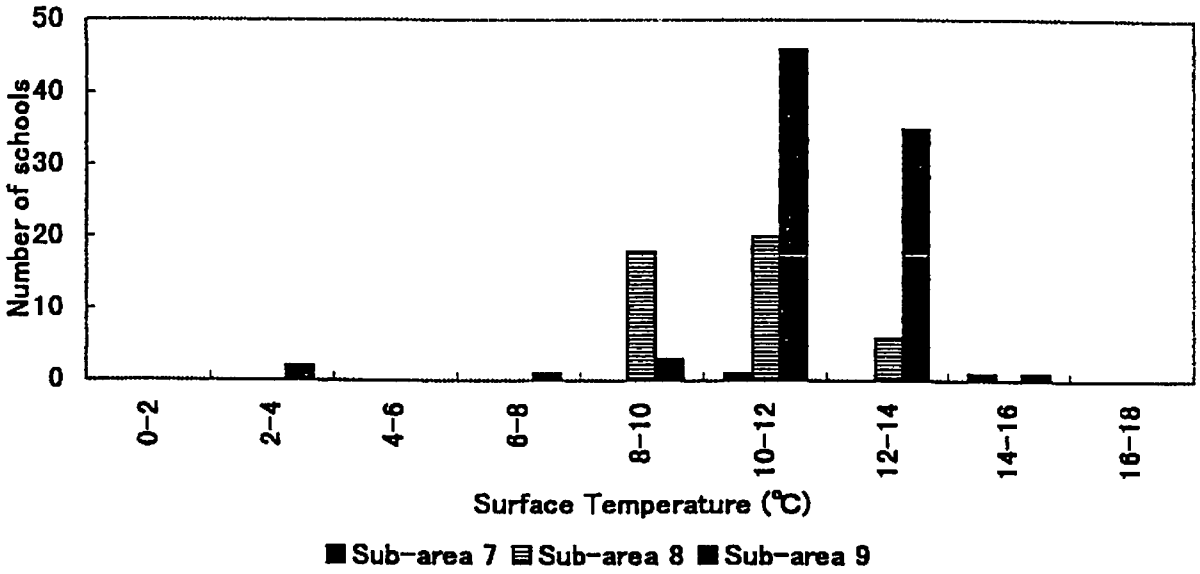

Fig. 6. Frequency distribution of sea surface temperature where minke whales were sighted in each sub-area.

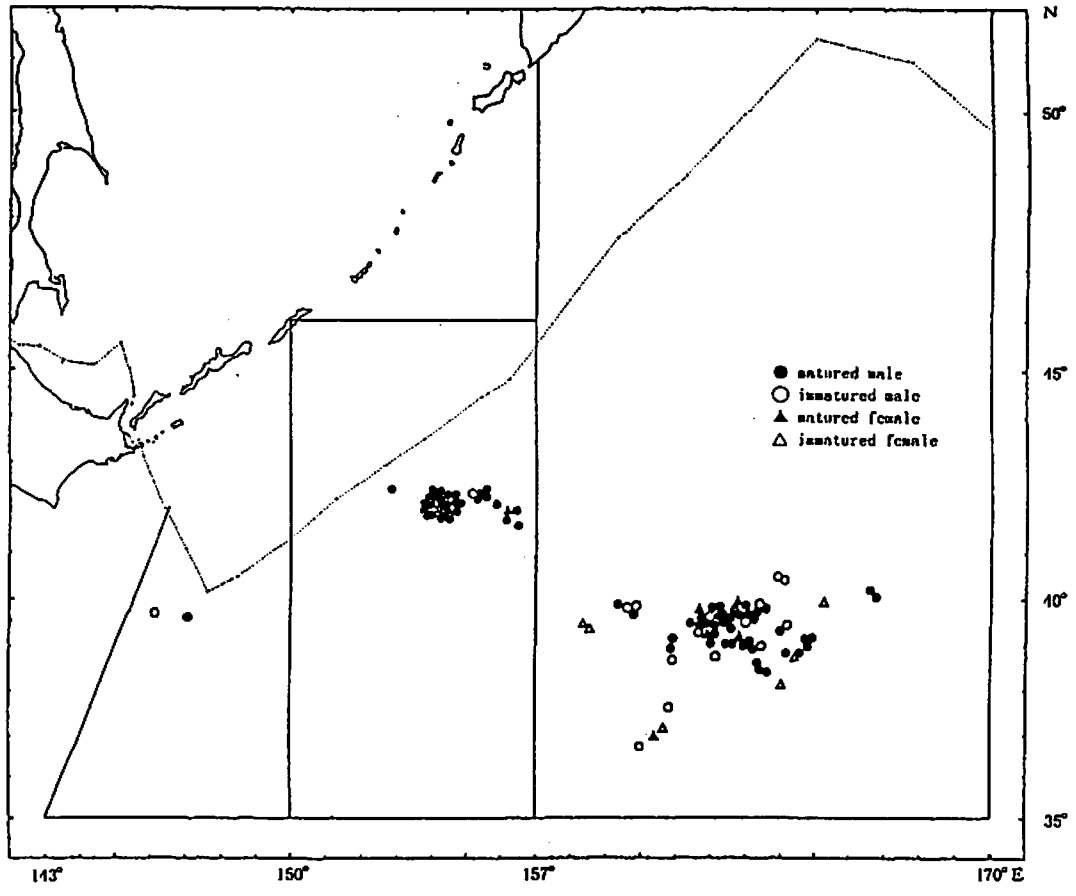

Fig. 7. Distribution of sampled minke whales by sex and reproductive status. Maturity of male was tentatively classified by the weight of testis.

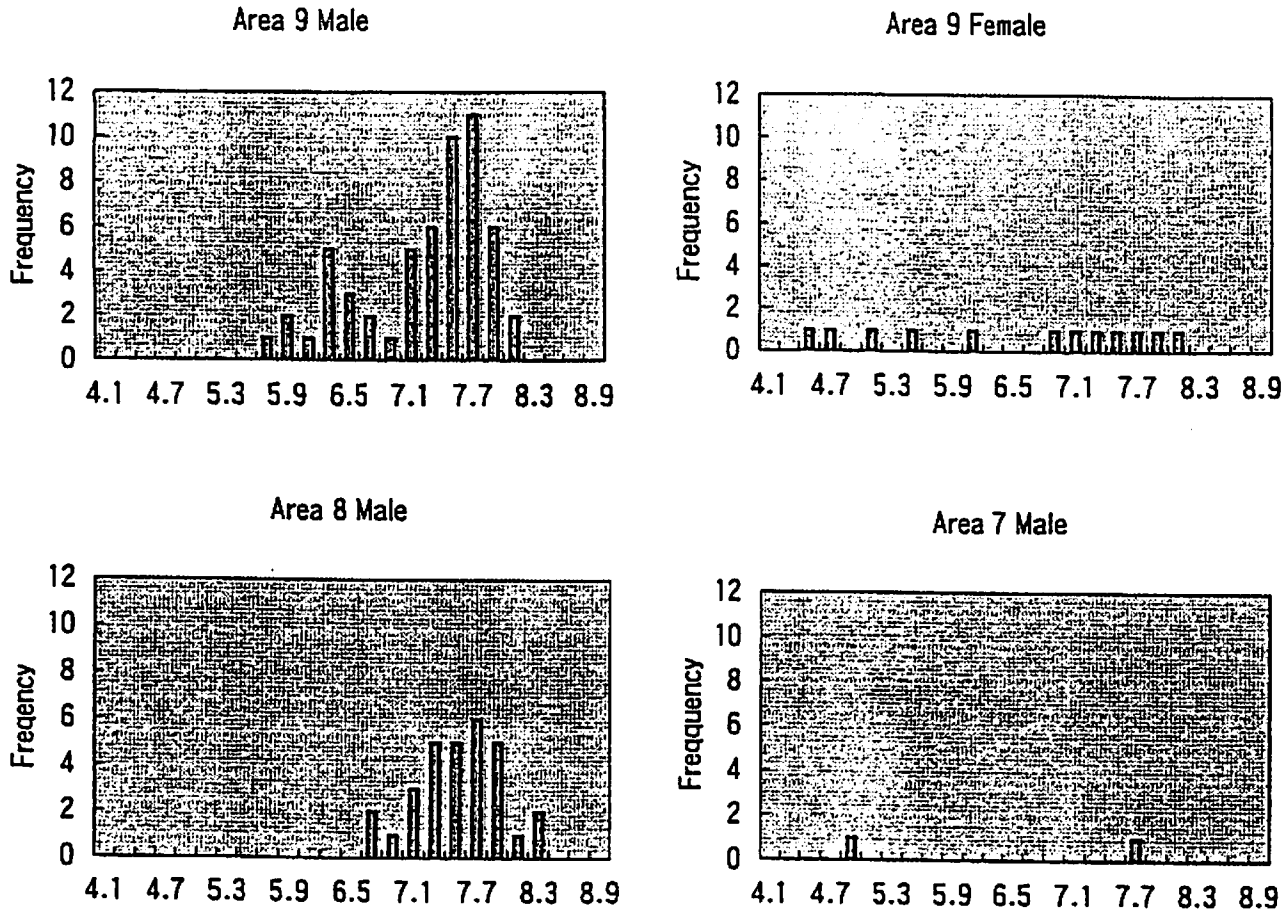

Fig. 8. Frequency distribution of body length of minke whale collected in the 1997 JARPN survey.

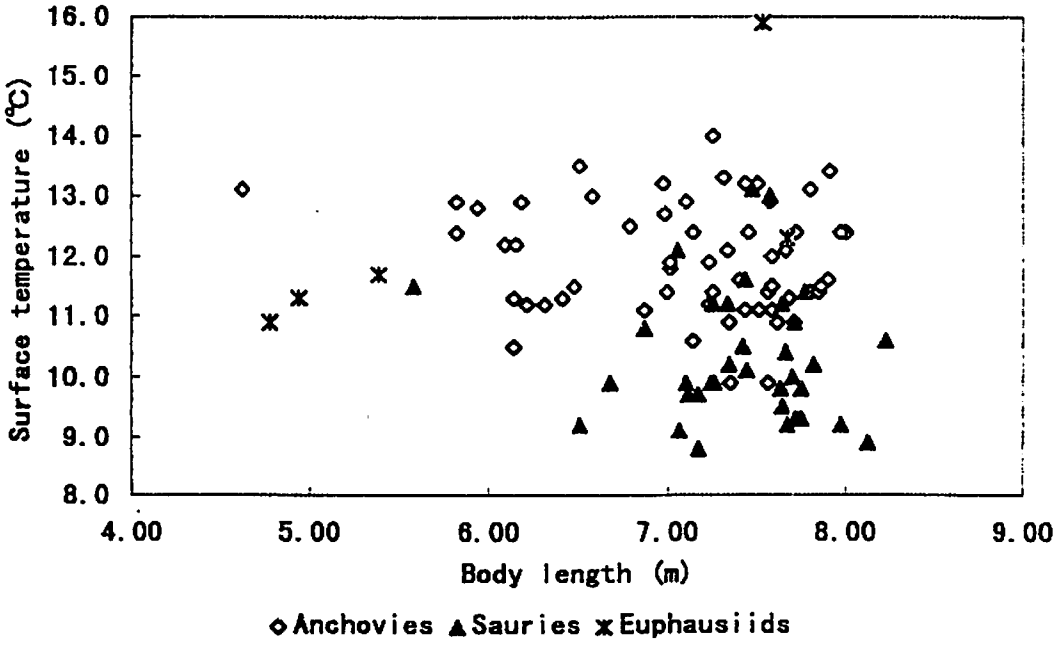

Fig. 9. Relationship among surface temperature, body length and food species.