An Examination of the W-Stock Hypothesis for North Pacific Minke Whales, with Special Reference to Some Biological Parameters Using Data Collected from JARPN Surveys from 1994 to 1997

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ABSTRACT

The 1997 JARPN survey was conducted in the sub-areas 9, 8 and 7E (eastern half) from 6 May to 14 July. The main objectives in this survey was to clarify the stock structure of minke whales in the earlier timing of the migration to sub-area 9. Of 100 whales sampled during the cruise, 60 samples were collected in such earlier timing (in early May to early June). Comparison of some biological parameters was made between based on the samples the 1997 JARPN and the previous JARPN surveys conducted in the sub-areas 9, 8, 7 E, 7W (western half) and 11 in the mid-summer season. High proportion of male in the 1997 samples is common phenomenon among other region in the mid-summer. Apparent pregnancy rate, conception date and occurrence of anomalous testes estimated by the 1997 JARPN samples were also similar to those by the previous samples in offshore region (sub-areas 9 and 8) in the mid-summer season. Overall results obtained from the 1997 JARPN samples indicate no evidence to support the existence of the W stock in the sub-area 9.

INTRODUCTION

In 1993, the working group on North Pacific minke whale management trials proposed two hypotheses in addition to the previous studies which identified two stocks around Japan. These were the 'existence of the W stock' and 'existence of sub-stocks within O and J stock' for North Pacific minke whales (IWC, 1994).

In response to these circumstances, the Government of Japan designed the JARPN (JApanese Whale Research Program under a Special Permit in the North Pacific) with the aim to elucidate the stock structure of the western North Pacific minke whale (Government of Japan, 1994). The JARPN survey began in 1994.

Results from the 1994-1995 JARPN surveys suggested no evidence for the existence of the 'W stock'. Partial results from this program were submitted to the 'North Pacific minke whale trials working group' convened by the Scientific Committee of the International Whaling

Commission (IWC/SC) in 1996 (IWC, 1997). During this working group meeting, it was pointed out that these results were derived from surveys conducted in the summer season. It was therefore agreed that these results were not conclusive because there was no information for the early migration season such as April and May (IWC, 1997).

The recent JARPN survey in 1997 was conducted to respond to the suggestion of the working group to survey in sub-area 9 earlier in the migrating season (May to June).

This paper presents a further examination of the W Stock hypotheses for the North Pacific minke whales, with special reference to some biological parameters using data collected from the JARPN surveys in 1994 to 1997.

MATERIALS AND METHODS

Materials used in this study are mainly 298 minke whales which were collected during the JARPN surveys from 1994 to 1997.

Table 1 shows the number of whales sampled during the JARPN surveys by month (early and late halves), sub-area and survey year. The first three surveys of the JARPN (1994-1996) were conducted mainly in the summer season. Most of the samples from these surveys were collected from late June to early September. The fourth JARPN survey (1997) was conducted in the early migrating season (early May to early July). Of 67 samples collected in the sub-area 9 in this survey, 60 samples were collected in the period from early May to early June.

Body length, sex and other biological information

Biological information such as body length, sex, stomach contents, number of foetuses (if present), foetal length and sex for these samples, was recorded on board the research base *Nisshin Maru* as well as the sampling date and location (Fujise *et al.*, 1995, 1996).

Stomach contents

The stomach contents of minke whales sampled are recorded conventionally for all the JARPN surveys (Fujise *et al.*, 1995, 1996, 1997; Ishikawa *et al.*, 1997). These records included major prey species, relative fullness of forestomach, and freshness of their contents. In this study, only major prey species are examined. Further detailed analyses of the feeding studies of the minke whales were reported by Lindstrøm *et al.* (1997) and Tamura *et al.* (1998). In the present studies, of 298 minke whales, a total of 263 individuals were examined. Rest of the remaining samples had no stomach content (10 individuals) and had the forestomach broken by the harpoon (25 individuals).

Sexual maturity

In the laboratory, sexual maturity for males was determined by examining testes histologically, and for females by examining ovaries, uterus and mammary glands by the naked eye.

Pathological examination of anomaly testis tissues

As reported in the previous cruise reports (Fujise *et al.*, 1995, 1996, 1997; Ishikawa *et al.*, 1997), anomaly was found in both (right and left) or either one of the reproductive glands (testes and epipidymes) in male whales sampled in the JARPN surveys. These showed transformation in part of or the entire tissue, with the finding of milk-white colour purulent

matter or those turned into lime. In this study, only the frequencies of anomalous gonads was examined. To allow closer examination later, these testes tissues were sampled and preserved in 10% formalin solution. The histological examinations and pathology are being conducted presently. These results will be reported in a future meeting.

RESULTS

1. Distribution of whale samples

Fig. 1 shows the geographical location of whales sampled during the JARPN surveys in 1994 to 1996. Fig. 1 also shows the actual searching trackline of these surveys. In sub-area 9, the searching effort was distributed in the northern part of the research area (north of 40N, excepting the EEZ zones of the foreign countries). Whale samples were distributed widely in this part of the research area. In the sub-areas 8 and 7(W), most of samples collected by the 1996 JARPN survey were collected near the northern boundary of the research area (which was determined by the foreign EEZ line).

Fig. 2 shows the same format for whales sampled and searching trackline for the 1997 JARPN survey. In the sub-area 9, the survey was conducted in the early migrating season (6 May to 19 June). During this time most of minke whales were sighted in the southern part of the sub-area 9. A similar trend was observed in the sub-area 8, where the whale sampled were taken somewhat south compared with the samples taken in the 1996 JARPN survey.

2. Body length and length distribution

Fig. 3 compares the length frequencies of male and female minke whales in each sub-area. The length frequency for males shows a similar peak value for all of sub-areas (about 7.4 or 7.6m). Small male animals were observed in the earlier migrating season in sub-area 9, as well as those in coastal sub-area such as sub-areas 7W and 11. In contrast, females seem to have a wider range of body length in all sub-areas. The same trends are observed for the earlier season in sub-area 9.

3. Sex ratio and maturity status

Table 2 shows the sex ratio, the maturity rate and maturity composition of whales sampled in sub-areas 7W, 7E, 8, 9 and 11.

In the summer season, male minke whales, especially mature males are dominant in the Pacific side from coastal area (sub-area 7W) to offshore (sub-area 9). The proportion of mature males are 87.6%, 91.5% and 76.7% in sub-area 9, 8 and 7W, respectively. In contrast, a relatively higher proportion of females seems to have been present in sub-area 11.

During earlier period of the migration (May to June), a similar trend (lower proportion of females) was observed in the sub-area 9. The mature males comprised 64.2% of the samples. However, if the ratio of immature individuals is compared to those for the summer seasons in this sub-area, a relatively high number of immature animals was observed in this period.

4. Apparent pregnancy rate

Table 2 also shows the number of pregnant females. Information on their foetuses is shown in

Table 3 separately.

Although the number of pregnant samples is too small for all sub-areas, the apparent pregnancy rate tends to be indicated higher in the offshore areas such as sub-areas 9 and 8 (100%), and relatively lower value of the rate was observed for those in the coastal areas such as sub-areas 7W and 11 (50.0% - 71.4%). This higher pregnancy rate in sub-area 9 was also observed in both the early season of migration (1997 samples) and the summer season (1994-1995 samples).

5. Foetal size (conception date)

In the earlier migrating season in sub-area 9, a total of 12 females were sampled, of which five were sexually matured and had a foetus.

Table 3 shows body length and sex of these foetuses with biological data for their mothers, as well as data for other foetuses collected during the JARPN surveys in 1994–1997. The smallest foetus was collected on May 8, 1997, and was 1.7cm.

Fig. 4 shows the relationship between the sampling date and the body length of these foetuses. This figure also shows data for those sampled in other sub-areas during the past Japanese coastal whaling. The sampling date in this figure is expressed as cumulative days on 1st March. All foetuses were considered to have been conceived at roughly the same time as for the Okhotsk-Western North Pacific stock (O stock)(e.g. winter breeding stock).

6. Anomaly in gonadal tissues of sampled whales

Table 4 shows the frequencies of male animals that have anomalous testis tissues by sub-area and maturity.

Of 259 males observed during the cruise, 52 males (20.1%) have anomalous tissues in both or either side of testis. Most of these anomalous testis were observed in mature individuals (98.1%). If the frequencies of the anomaly for mature males is compared between sub-areas, relatively higher frequencies of the anomaly were observed for mature animals collected in the offshore area such as sub-areas 9 and 8. These ratios are 20.1% and 37.2% for sub-areas 9 and 8, respectively. A similar trend was observed in the animals in the sub-area 7W (17.4%). For sub-areas 7E and 11, especially sub-area 11, the value tends to be lower. However, the sample size was relatively small for both of these sub-areas.

7. Feeding habit

Table 5 shows the composition of dominant prey species found in the forestomach of minke whales in each of the sub-areas. In the Pacific sub-areas (sub-areas 7W, 7E, 8 and 9), Pacific saury (*Cololabis saira*) was the dominant prey species (33.3-85.7%) except the earlier migrating season in sub-area 9. In the earlier season, minke whales consumed mainly Japanese anchovy (*Engraulis japonicus*) which comprised 96.4% of the stomach contents.

DISCCUSSION

One of major objectives of the 1997 JARPN survey was to respond to comments made by the North Pacific minke whale trials working group. This working group noted that 'the seasonal

coverage of the samples from sub-area 9 did not include the period from April to May' (IWC, 1997). Therefore, the 1997 survey was conducted in the sub-area 9 in the early migrating season (May to June). As a result, 67 minke whales were sampled in the sub-area 9. Of these, 60 samples were collected during early May to early June.

In this section, we discuss the possibility of the W stock in the offshore area (sub-area 9).

Distribution of samples collected in the 1997 survey was more southerly compared with the samples in the previous JARPN surveys. This geographical difference maybe due to the survey period. Former survey was conducted in the early migrating season, while the later was in summer season, therefore the differences in the distributions of whales sampled maybe explained by the timing of seasonal movement to the northward and the northward movement of the prey species such as Pacific sauries and anchovies.

The sex ratio of samples in the 1997 survey showed high percentages of males and absence of mature females, similar to that of samples collected in the summer season in the 1994 and 1995 surveys. No significant difference of apparent pregnancy rates in sub-area 9 was observed for samples between in the early migrating season and the summer season.
As well as the previous examinations (IWC, 1997), the present results suggest that no evidence was observed for the samples representing an independent population. Furthermore, the proportion of immature animals was relatively high in the samples from the 1997 survey (17.9% for male, and 10.4% for female) compared with those from the 1994-1995 surveys. Segregation by sex and maturity stage had been already reported for the North Pacific minke whale (Matsuura, 1936; Omura and Sakiura, 1956; Ohsumi, 1983; Wada, 1989). These seasonal change of the proportion of immature animals maybe due to these segregation.

As well as the similarity of the sex ratio of the 1997 early samples with that of previous years, data also suggested the same peak of conception date for samples both in the 1997 and 1994-1995 surveys. The frequencies of anomalous gonads for males was also the same for these samples.

For the food items of the stomachs of minke whales, the only difference was observed between the samples taken in the early migrating season and the summer season. In the former samples the major food item was Japanese anchovy, which was different from that of samples collected in the summer season (Ishikawa *et al.*, 1997). In the summer season, it was reported that minke whales were mainly consuming large amounts of Pacific sauries (Lindstrøm *et al.*, 1997; Tamura *et al.*, 1998). However, it has also been reported that the major prey species changed within a season for the minke whales in the North-East Atlantic (Haug *et al.*, 1995). Earlier studies in Japan also reported the predominant prey species differed by the sub-area in the same summer season, such as in the Okhotsk Sea (krill) and the Pacific sub-areas (Pacific saury). Further, it has already been reported that the North Pacific minke whale fed on a large variety of prey species (Omura and Sakiura, 1956; Kasamatsu and Hata, 1985; Kasamatsu and Tanaka, 1992). Differences in prey species between samples in the early migrating season and summer season in the sub-area 9 require careful consideration, especially for the interpretation of results of studies on parasites incidence and accumulation of pollutants such as Hg and PCBs.

As a conclusion, it was not possible to identify differences between some of the biological information from the samples in the early season (May to June) and those from the summer

seasons (June to September) previously reported (Fujise *et al.*, 1997).

The results of this study are consistent with those of genetic studies such as mtDNA RFLP and microsatellite analyses (Goto and Pastene, 1998). However, definitive conclusions concerning stock structure require comprehensive interpretation of results obtained by different approaches such as pollutant studies, morphology and parasite study, as well as additional genetic studies using mtDNA sequencing and nuclear analyses, which have higher resolution power than the mtDNA RFLP analysis.

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Table 1. Number of samples collected during the JARPN surveys in 1994 to 1997 by sub-area, month . and survey year

Survey year	Sub-area	Month										Total
		May		June		July		August		September		
		Early	Late	Early	Late	Early	Late	Early	Late	Early	Late	
1994	9					1	7	3	6	4		21
1995	9				14	27	34	25				100
1996	7E					1						1
	7W								15	15		30
	8						11	5				16
	11							1	29			30
1997	7E				2							2
	8					31						31
	9	7	20	33	7							67

Table 2. Compositon of sex and sexual maturity of minke whales collected by the JARPN surveys during 1994 and 1997.

Sub-area	Survey year	Surveyed month	Sample size	Male		Female			Sex ratio	Maturity rate	
				Imm.	Mat.	Imm.	Mat.*	[Preg.]	(% males)	Male	Female
9	1997	May-June	67	12 (17.9)	43 (64.2)	7 (10.4)	5 (7.5)	[5]	82.1	78.2	41.7
	1994-1995	June-Sep.	121	3 (2.5)	106 (87.6)	4 (3.3)	8 (6.6)	[8]	90.1	97.2	66.7
8	1996-1997	July-Aug.	47	3 (6.4)	43 (91.5)	0 (0)	1 (2.1)	[1]	97.8	93.5	100
7E	1996-1997	July	3	1 (33.3)	1 (33.3)	0 (0)	1 (33.3)	[1]	66.7	50.0	100
7W	1996	Aug.-Sep.	30	5 (16.7)	23 (76.7)	0 (0)	2 (6.7)	[1]	93.3	82.1	100.(
11	1996	Aug.	30	2 (6.7)	17 (56.7)	4 (13.3)	7 (23.3)	[5]	63.3	89.5	63.6

Figure in parenthes indicate percentage to the total

*: Mature females including pregnant females.

Table 3. Summary of pregnant females and their foetuses collected in the JARPN surveys during 1994 and 1997.

Sampling Date	Sub-area	Body length (m)	Blubber thickness (cm)	Foetus		
				Length (cm)	Weight (kg)	Sex
1997/5/8	9	6.97	3.0	1.7	0.001	U
1997/5/30	9	7.61	4.0	26.4	0.25	M
1997/6/1	9	7.50	3.9	40.8	0.88	M
1997/6/6	9	7.80	2.4	30.6	0.39	M
1997/6/11	9	8.00	4.0	21.0	0.14	F
1995/7/6	9	8.02	4.2	61.4	3.0	M
1997/7/8	8	7.75	3.6	18.6	0.092	M
1996/7/13	7E	7.93	2.9	44.3	1.1	F
1995/7/22	9	7.60	3.4	9.3	0.02	F
1995/7/23	9	7.45	4.3	79.7	6.3	F
1995/7/24	9	8.05	2.9	55.6	2.6	F
1995/7/25	9	7.95	3.0	49.6	1.8	F
1995/8/1	9	8.18	3.9	76.8	6.3	F
1995/8/9	9	8.01	3.0	73.8	5.8	M
1996/8/18	11	7.57	3.7	91.5	9.7	M
1996/8/18	11	7.95	4.0	89.6	9.1	F
1994/8/19	9	7.55	3.6	94.2	12.2	F
1996/8/19	11	8.05	5.0	127.0	27.4	F
1996/8/19	11	8.02	4.0	67.8	4.7	F
1996/8/20	11	7.92	4.4	94.8	12.7	F
1996/9/3	7W	8.45	4.4	112.0	13.7	F

Table 4. Freqencies of male whales with anomalous testes tissues, by maturity of animals, area and year.

Sub-area	Year	Maturity	n	Normal	Anomalous			
					Both side	One side	Combined n	(%)
9	1994-1995	Imm	3	3	0	0	0	(0.0)
		Mat	106	84	6	16	22	(20.8)
	1997	Imm	12	12	0	0	0	(0.0)
		Mat	43	35	2	6	8	(18.6)
	Combined	Imm	15	15	0	0	0	(0.0)
		Mat	149	119	8	22	30	(20.1)
8	1996	Imm	2	1	1	0	1	(50.0)
		Mat	14	6	0	8	8	(57.1)
	1997	Imm	1	1	0	0	0	(0.0)
		Mat	29	21	1	7	8	(27.6)
	Combined	Imm	3	2	1	0	1	(33.3)
		Mat	43	27	1	15	16	(37.2)
7E	1996	Imm	0					
		Mat	0					
	1997	Imm	1	1	0	0	0	(0.0)
		Mat	1	1	0	0	0	(0.0)
	Combined	Imm	1	1	0	0	0	(0.0)
		Mat	1	1	0	0	0	(0.0)
7W	1996	Imm	5	5	0	0	0	(0.0)
		Mat	23	19	0	4	4	(17.4)
11	1996	Imm	2	2	0	0	0	(0.0)
		Mat	17	16	0	1	1	(5.9)
Total		Imm	26	25	1	0	1	(3.8)
		Mat	233	182	9	42	51	(21.9)
		Combined	259	207	10	42	52	(20.1)

Table 5. Food species of North Pacific minke whales and their frequency of occurrence by sub-area

Food species		Sub-area and season												Combined	
		11 * (Aug.)		7W * (Aug.-Sep.)		7E ** (July)		8 ** (July-Aug.)		9 *** (May-June)		9 **** (June-Sep.)			
		n	(%)	n	(%)	n	(%)	n	(%)	n	(%)	n	(%)	n	(%)
Euphausiacea	Euphausiids (*Euphausia pacifica*)	22	(100)	10	(38.5)			1	(2.4)			2	(1.8)	35	(13.3)
	Euphausiids (*Thysanoessa* spp.)											4	(3.5)	4	(1.5)
	Unidentified Euphausiids					2	(66.7)			1	(1.8)	1	(0.9)	4	(1.5
Copepods	Copepods (*Neocalanus* sp.)											1	(0.9)	1	(0.4)
Sauries	Pacific saury (*Cololabis saira*)			13	(50.0)	1	(33.3)	36	(85.7)	1	(1.8)	86	(75.4)	137	(52.1)
Anchovies	Japanese anchovy (*Engraulis japonicus*)							4	(9.5)	54	(96.4)	15	(13.2)	73	(27.8)
Mackerels	Chub mackerel (*Scomber japonicus*)							1	(2.4)					1	(0.4)
Pomfrets	Japanese pomfret (*Brama japonica*)											1	(0.9)	1	(0.4)
Salmonids	Pink salmon (*Oncorhynchus gorbuscha*)											1	(0.9)	1	(0.4)
	Unidentified salmon											1	(0.9)	1	(0.4)
Barracudas	Unidentified barracuda											2	(1.8)	2	(0.8)
Cods	Walleye pollock (*Theragra chalcogramma*)			3	(11.5)									3	(1.1)
No. whales observed		22	(100)	26	(100)	3	(100)	42	(100)	56	(100)	114	(100)	263	(100)

*: Date from the 1996 JARPN survey.

**: Date from the JARPN surveys in 1996 and 1997.

***: Data from the 1997 JARPN survey.

****: Date from the JARPN surveys in 1994 and 1995.

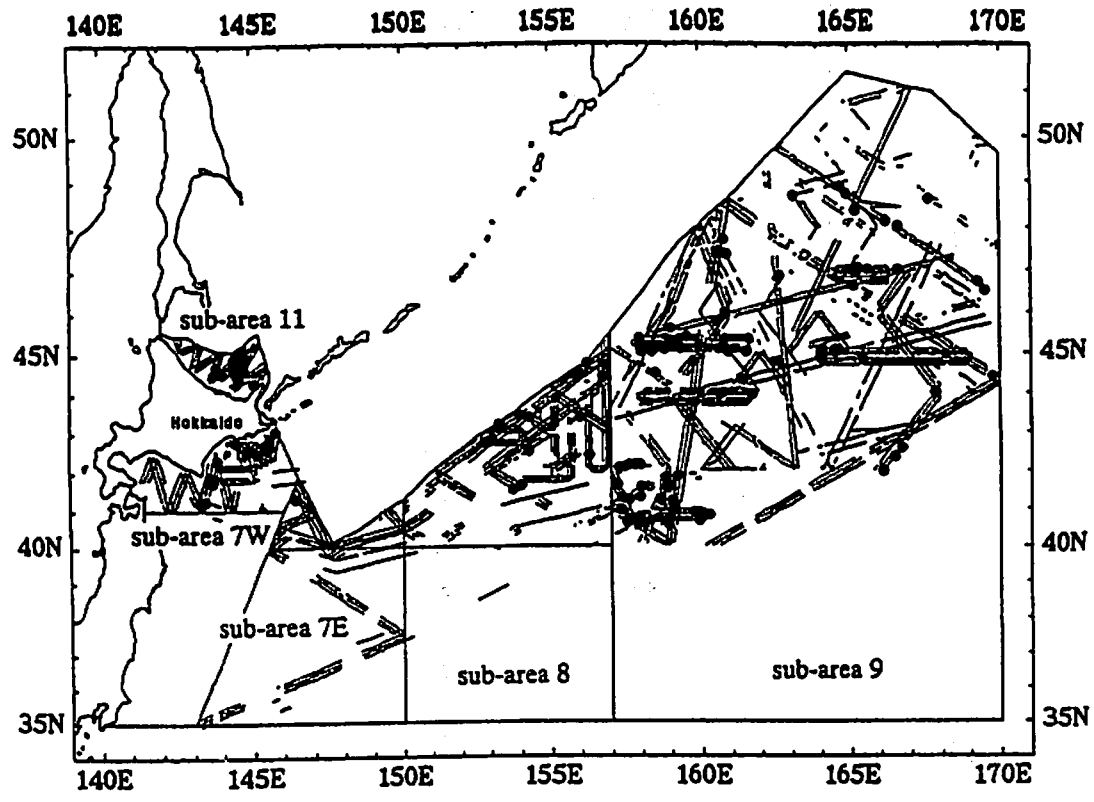

Fig. 1. Distribution of minke whales sampled and searching tracklines in the JARPN surveys during 1994 and 1996.

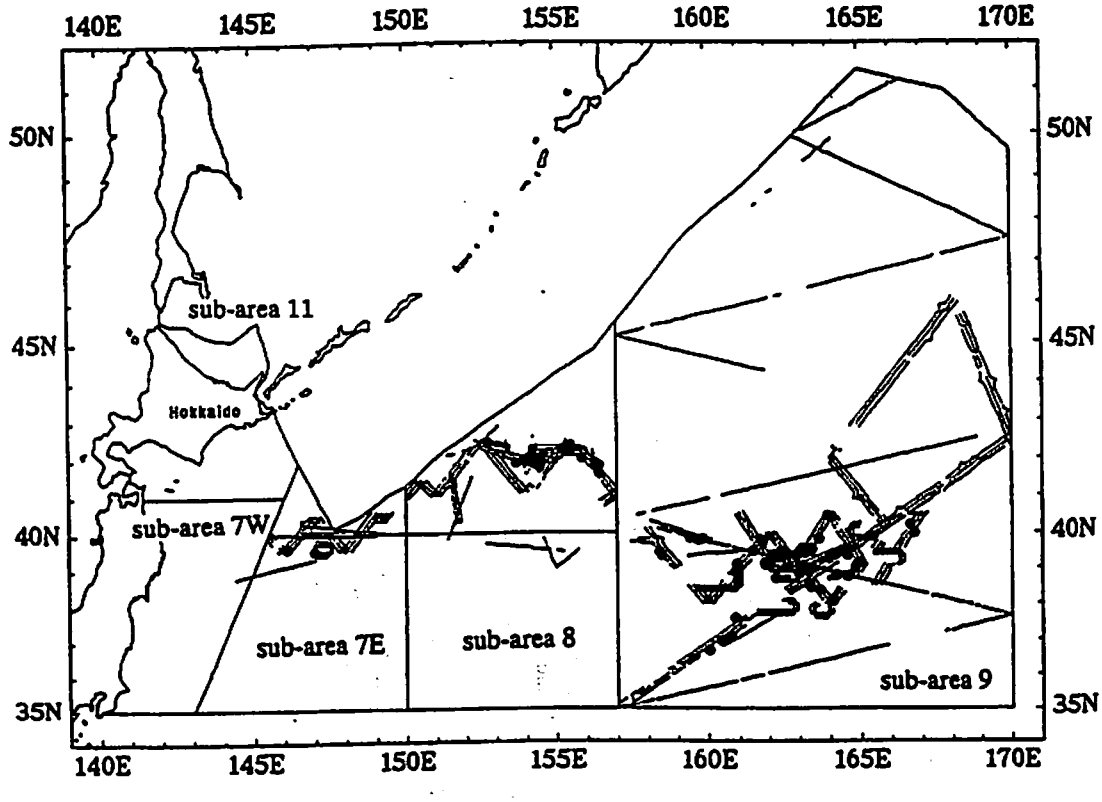

Fig. 2. Distribution of minke whales sampled and searching trackline in the 1997 JARPN survey.

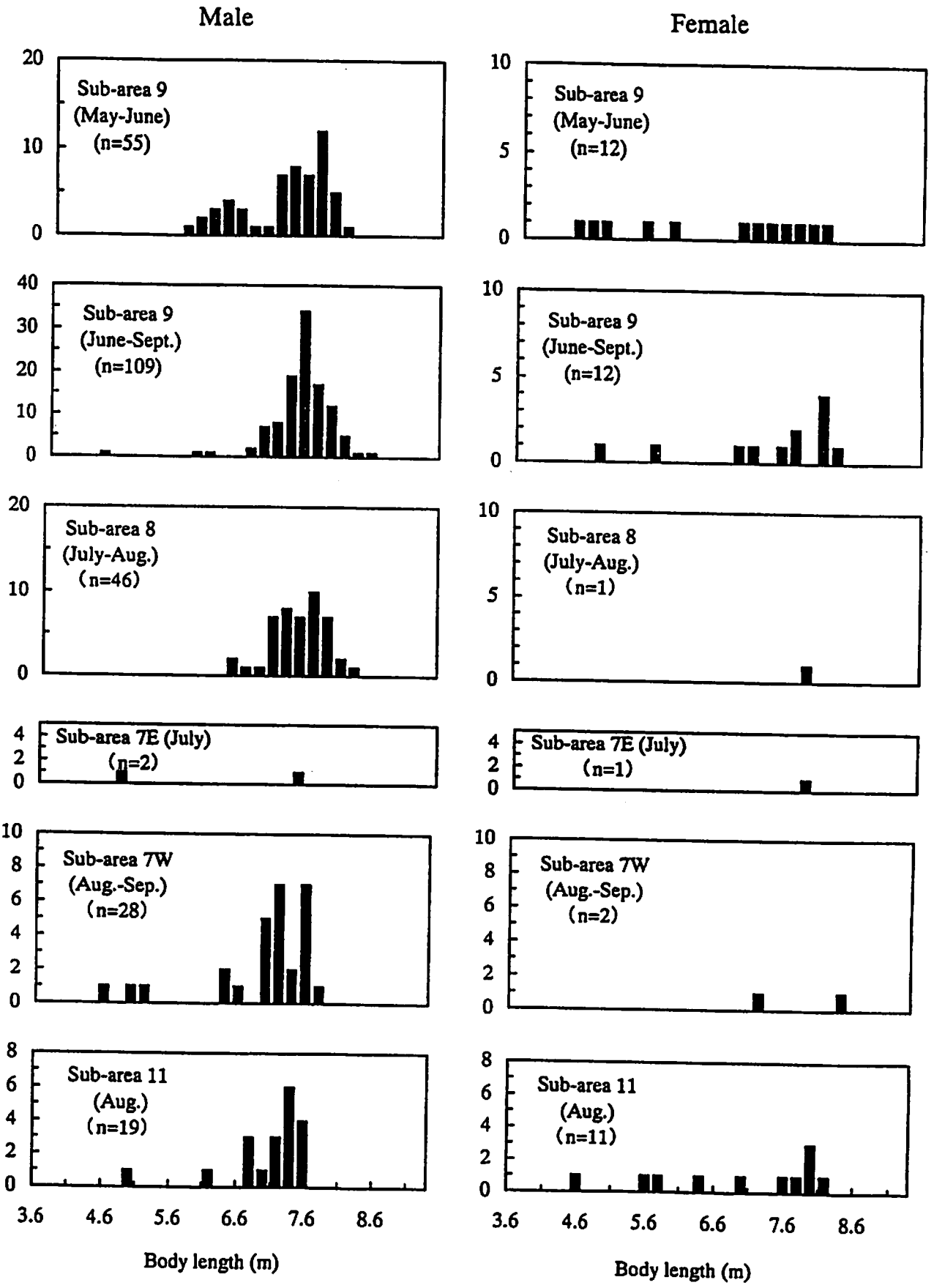

Fig. 3. Comparison of body length frequencies of minke whales for male (left) and female (right) in sub-areas 9, 8, 7E, 7W and 11.

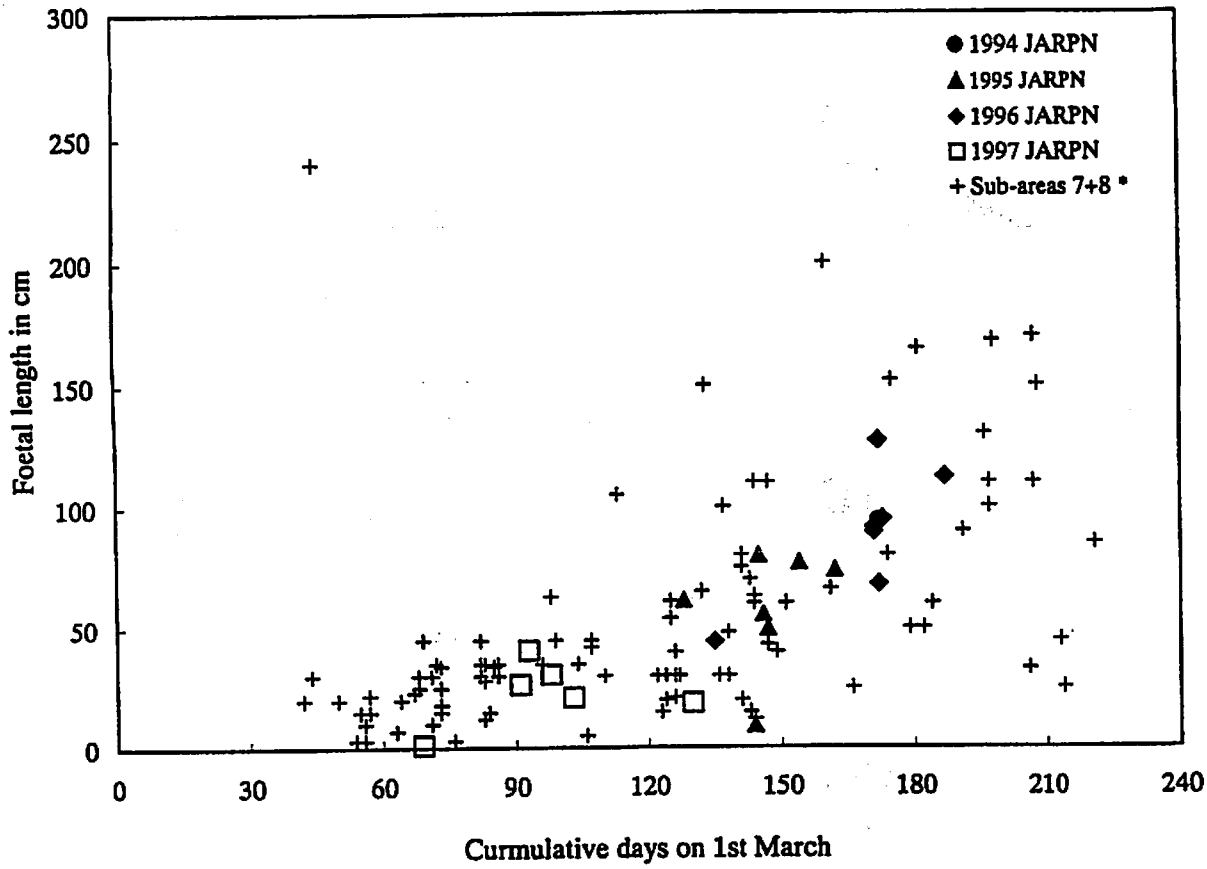

Fig. 4. Relationship between length of foetuses and collection date in minke whales collected from Japanese coastal whaling which operated in sub-areas 7 and 8 (Kato, 1993) and from the JARPN surveys in 1994-97 which were conducted in sub-areas 7, 8, 9 and 11.