Preliminary analyses on prey consumption by fin whales based on JARPAII data

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ABSTRACT

In this study, the information on the feeding habits of fin whales (*Balaenoptera physalus*) sampled during the surveys of the second phase of the Japanese Whale Research under Special Permit in the Antarctic (JARPAII), for the period 2005/06-2010/11 (n= 16) was summarized. The fin whales fed mostly on Antarctic krill (*Euphausia superba*) in the research area. The daily prey consumption by fin whales per capita using three methods ranged between 276kg and 2,136kg. These values were equivalent to 0.50 and 3.84% of the body weight. The seasonal prey consumptions for all fin whales in the total research area based on three methods were 0.54-0.78million tons, 3.38-4.51million tons and 2.19-2.93 million tons, respectively. There was coincidence in the frequency of body length of the *E. superba* consumed by fin and Antarctic minke whales (*B. bonaerensis*). It seems that fin and Antarctic minke whales have similar feeding habits with no prey size selectivity

KEYWORDS: FEEDING; ENERGETICS; FOOD/PREY; MODELLING; SCIENTIFIC PERMITS; ANTARCTIC; ANTARCTIC MINKE WHALE; FIN WHALE

INTRODUCTION

Fin (*Balaenoptera physalus*) and Antarctic minke (*B. bonaerensis*) whales are the dominant whale species in the Antarctic, which migrate to this area in austral summer for feeding with other baleen whale species (Kawamura, 1980). The feeding method of both species is swallowing. The dominant prey species of these whales is the Antarctic krill, *Euphausia superba*. *E. superba* predominates over the Antarctic Oceans, and is not only the prey of baleen whales but also the prey of most marine mammals, such as seals, sea-birds, fish, squids and benthic animals.

In the Antarctic Ocean, commercial whaling first began with blue whales and humpback whales. The level of catches on these two species increased rapidly, and the stocks were greatly depleted. Next, whaling moved to fin whales in the mid 1930s, and the stocks of this species were again severely depleted. The substantial reduction in abundance of these species, which are important components of the ecosystem, resulted in a substantial surplus of krill (Krill surplus hypothesis; *e.g.* Laws, 1977). The catches of humpback, blue and fin whales were banned in 1963, 1964 and 1976, respectively. The increasing trend of the humpback and fin whales' abundance has become apparent in recent years (Matsuoka *et al*., 2005; Branch, 2006). The composition of baleen whale species in the Antarctic ecosystem is changing.

According to Ruud (1932), the Norwegian whalers understand well 'blue whale krill' and 'fin whale krill' meaning 1year and 2year groups of *E. superba,* respectively. Peters (1955) noted that blue whales fed mainly on the krill of 20 to 30mm in body length, on the other hand, fin whales fed mainly on 30-40mm in body length. He considered that the difference in body lengths was the sampling period, because blue whales migrate earlier to the Antarctic than fin whales.

There is no information on the feeding ecology of the fin whale since commercial whaling of this species stopped in the Antarctic some 36 years ago. This study provides new information on the feeding ecology of the fin whale based on whales sampled during the JARPAII. Specifically this study presents information on prey composition and daily prey consumption rate. Furthermore the size of the *E. superba* consumed by fin whales is compared with that consumed by the Antarctic minke whales. The information on prey consumption of fin whales in this paper can contribute to the development of ecosystem models in the research area.

MATERIALS AND METHODS

Research area and period

Data used in the present study was collected during the surveys of the JARPAII in the International Whaling Commission (IWC) Antarctic management Areas III-East (35°-70°E), IV (70°-130°E), V (130°E-170°W including the Ross Sea) and VI-West (170°-145°W), south of 62°S (Fig. 1). The surveys were conducted mainly from December to March between the 2005/06 and 2010/11 seasons.

Sighting and sampling methods
The survey track line was designed along each 10 degree longitudinal width interval in principle. The survey starting point was randomly selected from the arrangement of the survey track line and longitude standard lines in the survey. Sighting procedures were the same as in the previous JARPA surveys (Nishiwaki *et al*. 2006, 2014). The survey was operated under optimal research conditions (when the wind speed was below 25knots in the south strata and below 20knots in the north strata, and when visibility was more than 2n.miles). SSVs advanced along parallel track lines 7n.miles apart from each other at a standard speed of 11.5knots. The sampling activity was focused to the area south of 62°S as mentioned in the original plan (Government of Japan, 2005). The sampling of fin whales was restricted to animals with an estimated body length of less than 20m due to technical limitations on the research base vessel (*NM*), and to avoid any handling accidents.

Sample size and biological research
After capture, the animals were placed aboard a research base vessel where they were examined. A total of 17 fin whales were sampled by the JARPAII between the 2005/06 and 2010/11 seasons. This study used the data of 16 fin whales (Male 8; Female 8), because one fin whale was lost before landing on the flensing deck of the research base vessel (Table 1). Body length of the whales was measured to the nearest 10cm from the tip of the upper jaw to the deepest part of the fluke notch in a straight line. Sex and maturity were recorded for each whale on the basis of routine observations of reproductive organs during dissection and tissue observations in the laboratory. Body weight was measured using a large weighing machine to the nearest 50kg.

Analytical procedure of the daily prey consumption
The uncertainty in several components involved in estimating the amounts and types of prey consumed by whales was assisted by a recent review by Leaper and Lavigne (2007) and Tamura *et al*. (2009). They considered that the appropriate consumption estimates is between the high end of Equation 1 and the low end of Equation 2. The estimate of consumption by Equation 3 was considered by the authors at the upper range of these reasonable values. I also estimated using Equation 4. Equation 4 which was used by Hunt *et al*. (2000) in PICES region was applied to the Antarctic Peninsula marine ecosystem model and simulation by Hoover *et al*. (2012).

Equation 1: $R = 0.42\ W^{0.67}$ (Innes *et al*., 1986) (1)
Equation 2: $FMR = 2529.2\ W^{0.524}$ (Boyd, 2002) (2)
Equation 3: $FMR = 863.6W^{0.783}$ (Sigurjónsson and Víkingsson, 1997) (3)
Equation 4: $FMR = 803.9W^{0.75}$ (Perez *et al*, 1990) (4)

R is the daily prey consumption (expressed by kg) and *W* is body weight in kg. *FMR* is the daily prey consumption (expressed in KJ d^{-1}) and *W* is body weight in kg. It should be noted here that the estimates from Equation 1 depend only on the body weight data (expressed in kg). The estimates from Equations 2, 3 and 4 require body weight data (expressed in kg) and energy content of prey (expressed in kJ kg^{-1}). For comparative analysis, it was assumed that the energy content of prey and assimilation efficiency was 4,473kJ kg^{-1} (*E. superba*; this value was measured by bomb calorimeter (n=1)) and 84% (Lockyer, 1981a), respectively. Therefore, the energy value of prey items of whales was estimated to be 3,757kJ kg^{-1}. I compared daily prey consumption of fin whales among Equations 2, 3 and 4 in this study.

Estimation of seasonal prey consumption in Areas III east, IV, V and VI west
The seasonal prey consumption by all fin whales in each sub area was estimated using information on abundance, body weight and residence days in the feeding ground. The information on abundance of fin whales was described in Matsuoka and Hakamada (2014). Average body weight of female and male fin whales in the Antarctic was estimated at 59,800 and 51,400kg, respectively (Trites and Pauly, 1998). Therefore the weight of "average sized" fin whales was estimated to be 55,600kg.

Baleen whales are generally known to migrate between feeding grounds in high latitudinal waters in summer and the breeding grounds in low latitudinal waters in winter. The ratio of high to low feeding seasons and the proportion of the energy intake per year during the high feeding season are assumed without actual data. This could bring some uncertainty to the estimations.

For example Lockyer (1981a) indicated that around 83% of the annual energy intake in Southern Hemisphere balaenopterid species is ingested during the high feeding season (*HF*=120days) and predicted that 17% of annual food intake for Southern Ocean balaenopterid species was outside the high feeding period. In this case, the ratio of low feeding season (*LF*)/high feeding season (*HF*) intake (*r*) is 0.10. Leaper and Lavigne (2007) estimated the *r* to be from 0.34 (Antarctic minke whales) to 0.62 (North Atlantic minke whales) based on other sources.

The relationship between the rate of daily consumption during the high feeding season (*RCH*) and *r* is shown in following equation.

$RCH = 365 / (HF\ (\text{days}) * 1 + LF\ (\text{days}) * r)$ (5)

Hinga (1979) assumed that baleen whales spend 120 days in the Antarctic feeding area (*HF*). I estimated *RCH* based on the three following cases using Equations 2, 3 and 4.

Case-1: *RCH*=1.34 (6)

High feeding days (*HF*) 120days, Low feeding days (*LF*) 245days. Low feeding/High feeding intake (*r*)=0.62.

Case-2: *RCH*=1.79 (7)

High feeding days (*HF*) 120days, Low feeding days (*LF*) 245days. Low feeding/High feeding intake (*r*)=0.34.

Case-3: *RCH*=2.53 (8)

High feeding days (*HF*) 120days, Low feeding days (*LF*) 245days. Low feeding/High feeding intake (*r*)=0.10.

The assumption of the resident period of fin whales in the Antarctic was 120days, but fin whales feed on various prey during their non-resident period in the Antarctic (Kawamura, 1980). *r*=0.01 does not seem appropriate for this estimation of prey consumption. I chose cases-1 (*RCH*=1.34; *r*=0.62) and 2 (*RCH*=1.79; *r*=0.34) in this study.

Analyses of the stomach contents

The stomach contents were removed from forestomachs and fundus of each whale, and the contents of forestomachs were first classified into major prey groups, such as euphausiids, amphipod, copepods, fish and others onboard. The freshness of the stomach contents was recorded according to the following categories (1=fresh (F), 2=lightly digested (fff), 3=moderately digested (ff), 4=heavily digested (f)). Then, the contents from the forestomach and fundus were weighed to the nearest 0.1kg. If prey species were found, we sampled a portion and placed it in 10% formalin solution water for later analyses. Fourteen sub samples of fin whales were collected. Prey species were identified to the lowest taxonomic level as possible using external morphology (Barnard, 1932; Fischer and Hureau, 1985a, b; Baker *et al*., 1990). To examine body length composition of *E. superba*, randomly taken specimens (between 50 and 100) from each sub sample was measured to the nearest 1mm, from the anterior tip of the rostrum to the posterior end of the telson described by Makarov and Denys (1981) and Mauchline (1981). To examine body length composition of *E. superba* between fin whales and Antarctic minke whales, I selected sub-samples of Antarctic minke whales, which were collected on the same days that fin whales were sampled (excluding eastern sector; Appendix 1). Finally nine sub-samples of fin whales and eight sub-samples of Antarctic minke whales were measured for this analysis.

RESULTS

Prey species composition

A total of four prey species, including one amphipod, one euphausiid and two fishes were identified from the stomachs of the fourteen fin whales (Table 2). The *E. superba* was the dominant prey species, found in almost 100% of the whales' stomachs examined in each area (Table 3). The position of fin whales and Antarctic minke whales sampled in this paper was shown in Fig. 2. It was confirmed that fin whales and Antarctic minke whales sampled near the position fed on *E. superba* in this study (Table 3 and Appendix 1).

Stomach contents weight and RSC

The average and maximum weight and the ratio of stomach contents weight to body weight, expressed as a percentage (RSC) of fresh or lightly digested stomach contents (freshness category F and fff) by different reproductive classes are shown in Table 4. The mean weight and RSC of stomach contents were 324.3±208.3kg (RSC:0.7%) and 665.6±592.7kg (RSC:0.8%) for males and females, respectively. The maximum weight and RSC of stomach contents (freshness categories F and fff) were 633.7kg (RSC:1.3%) and 1,084.7kg (RSC:2.0%) for males and females, respectively.

Per capita daily and seasonal prey consumption

The daily prey consumption of fin whales in each equation and *RCH* are shown in Table 5 and Fig. 3. In case 1 (*RCH*=1.34), the daily prey consumption by "average sized" fin whales was between 276kg and 1,599kg. These values were equivalent to 0.5 and 2.9% of body weight. In case 2 (*RCH*=1.79), the daily prey consumption by "average sized" fin whales was between 369kg and 2,136kg. These values were equivalent to 0.7 and 3.8% of body weight.

The stomach contents weight of fin whales sampled and estimated daily prey consumption by Antarctic minke whales (Tamura and Konishi, 2014) is shown in Fig. 3. If *RCH* was the same value (1.34 or 1.79), among the equations the highest value (Equation 3) of consumption was 5.8 times larger than the lowest one (Equation 2).

In case 1 (*RCH*=1.34), the per capita seasonal (120 days) prey consumption of average fin whales was between 33.1tons and 191.9tons. In case 2 (*RCH*=1.79), the per capita seasonal prey consumption by average fin whales was between 44.3tons and 256.3tons.

Seasonal prey consumption for all fin whales in the research area

In Areas III east and IV in the 2007/2008 season, the abundance was estimated to be 956 and 1,654, respectively. In Area V and VI west in the 2008/2009 season, the abundance was estimated to be 10,056 and 4,925, respectively (Table 6).

The seasonal prey consumptions for all fin whales in the total research area based on three methods were estimated to be 0.54-0.78 million tons, 3.38-4.51million tons and 2.19-2.93million tons, respectively (Table 6).

Length frequency distribution of *Euphausia superba* in the stomach

Western (Area IV 70-85E)

The sub-samples of six fin whales in the 2005/06 JARPAII were used for this analysis. The length distribution of *E. superba* fed on by fin whales is shown in Fig. 4 This distribution consists of unimodal compositions (modes at 40mm). The sub-samples of five Antarctic minke whales in the 2005/06 JARPAII were used for this analysis. The length distribution of *E. superba* fed on by Antarctic minke whales is shown in Fig. 4. This distribution consists of unimodal compositions (modes at 40mm). The body length composition of *E. superba* consumed by fin whales and Antarctic minke whales almost coincided.

Central (Area IV 114-121E)

The sub-samples of two fin whales in the 2005/06 JARPAII were used for this analysis. The length distribution of *E. superba* fed on by fin whales is shown in Fig. 5 This distribution consists of unimodal compositions (modes at 40mm). The sub-samples of two Antarctic minke whales in the 2005/06 JARPAII were used for this analysis. The length distribution of *E. superba* fed on by Antarctic minke whales is shown in Fig. 5. This distribution consists of unimodal compositions (modes at 45mm). The body length composition of *E. superba* consumed by fin whales and Antarctic minke whales almost coincided.

Eastern (Area V 163-166E)

The sub-sample of one fin whale in the 2008/09 JARPAII was used for this analysis. The length distribution of *E. superba* fed on by fin whales is shown in Fig. 6 This distribution consists of unimodal compositions (modes at 48mm). The sub-sample of one Antarctic minke whale in the 2008/09 JARPAII was used for this analysis. The length distribution of *E. superba* fed on by Antarctic minke whales is shown in Fig. 6. This distribution consists of unimodal compositions (modes at 45mm). The body length composition of *E. superba* consumed by fin whales and Antarctic minke whales almost coincided.

DISCUSSION

The main prey species of fin whales in our research area was *E. superba.* The present results were similar to those of previous studies (Nishiwaki and Hayashi, 1950; Nishiwaki and Oye, 1951; Mizue and Murata, 1951; Ohno and Fujino, 1952; Nemoto and Nasu, 1958). It was reported that fin whales fed mainly on other krill species such as *T. macrura*, *E. vallentini, E .frigida, E .lucens*, and *E .diomedeae* etc in middle and lower latitudes (north of 60 degree) in the Antarctic (Kawamura, 1974; Kawamura, 1980). The difference in prey species of fin whales depends on the prey distribution in the feeding area.

Some stomach contents data (N=5) of fin whales in the Antarctic was reported in Kawamura (1968). In this report, the average and maximum stomach contents weight were 404kg and 885kg, respectively. The results in this study were similar to the values in the previous report.

The uncertainty in several components involved in estimating the amount and types of prey consumed by whales was assisted by a recent review by Leaper and Lavigne (2007) and Tamura *et al.* (2009). The amount of krill consumed by Antarctic minke whales was estimated using two independent methods, which were from theoretical energy requirements calculations (method-1) and from diurnal changes of stomach contents (Total of forestomach (1st. stomach) and fundus (2nd. stomach)) (method-2) (Tamura and Konishi, 2014). The number of fin whales sampled in the JARPAII was too low to allow for the same kind of analyses. In this study, the prey consumption by fin whales was estimated using theoretical energy requirements calculations. Leaper and Lavigne (2007) considered that the appropriate consumption estimates are between the high end of Equation 1 and the low end of Equation 2. The estimate of consumption using Equation 3 was considered by the authors at the upper range of these reasonable values. The assumption of the resident period of fin whales in the Antarctic was 120days (Lockyer, 1981b), but fin whales feed on various prey during the non-resident period in the Antarctic (Kawamura, 1980). r=0.01 does not seem appropriate for this estimation of prey consumption. The cases-1 (r=0.62) and 2 (r=0.34) were chosen in this study. Leaper and Lavigne (2007) discussed these equations which involve values of $\beta > 0.75$ and their conclusion was that they were not supported either by theory or data. Based on the actual stomach contents data of the previous report and the JARPAII, the consumption under Equation 2 seems to be underestimated, because consumption estimates by this equation are similar to that of average stomach contents weight. On the other hand, the consumption under Equation 3 seems to be overestimated, because in case 1 (RCH=1.34) and 2 (RCH=1.79) in Equation 3, fin whales need to feed twice or three times in a day to reach full stomachs. Cases 1 and 2 of Equation 4 seem to be appropriate for prey consumption estimation of large baleen whale species. These values were equivalent to 2.2 and 2.9% of body weight. The validity of different models for estimating the total consumption can be investigated with additional data collected by the JARPAII in the future. It might be possible in the near future to provide estimates within a narrow range.

The body length composition of *E. superba* consumed by fin whales and Antarctic minke whales almost coincided in this study. It suggested that fin whales and Antarctic minke whales have similar feeding habits with no prey size selectivity in our research area and there was some inter specific interaction between them. In the present results, the size difference of the *E. superba* consumed by fin and Antarctic minke whales seems to depend on the size of *E. superba* distributed. The body length of *E. superba* fed on by whales in the western sector was smaller than that in the eastern sector. It seems to depend on seasonal and geographical factors.

In the JARPAII, prey species and their body composition coincided for fin whales and Antarctic minke whales. It was supported that there was some inter specific interaction between fin whales and Antarctic minke whales. More data on krill species and their body size fed on by humpback and blue whales in the Antarctic are needed before conclusions can be drawn with regard to the inter specific interaction among them. Many parameters for application in the multi-species ecosystem modelling should be improved in the future. Improving estimates of the daily and seasonal consumption by fin whales is also important. These results are useful to apply as input data regarding daily consumption by fin whales in the development of ecosystem models (e.g. Kitakado *et al*., 2014).

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Table 1

Sample size of fin whales used in this study

Area	Area III-East		Area IV		Area V			Total		
Sex	Male	Female	Male	Female	Male	Female	Unknown	Male	Female	Unknown
Number	1	0	4	6	3	2	1	8	8	1

Table 2

Prey species of fin whales sampled by the JARPAII

	species
Main prey	
Krill	*Euphausia superba*
Minor prey	
Amphipoda	*Parathemisto gaudichaudi*
Pisces	*Pleuragramma antarcticum*
	Notolepis coatsi

Table 3

Composition of prey found in the stomachs of fin whales sampled by the JARPAII

Species		Area III-E	Area IV	Area V
Krill	*Euphausia superba*	100.0	100.0	100.0
Amphipods	*Parathemisto gaudichaudi*	0.0	< 0.01	< 0.01
Fish	*Pleuragramma antarcticum*	0.0	0.0	< 0.01
	Notolepis coatsi	0.0	< 0.01	0.0

Table 4

Stomach contents weight (kg) and RSC of fin whales

Sex	Number	Weight (Categories F and fff)		
		Average	S.D.	Maximum
Male	4	324.3	208.3	633.7
		(RSC: 0.7%)		(RSC: 1.3%)
Female	3	665.6	592.7	1,084.7
		(RSC: 0.8%)		(RSC: 2.0%)

Table 5

The daily prey consumption of fin whales in each equation and *RCH*. B.W. is body weight (kg).

Equation 2 Boyd (2002) $FMR = 2529.2W^{0.524}$			Equation 3 Sigurjonsson and Vikingsson (1997) $FMR = 863.6W^{0.783}$			Equation 4 Perez *et al* . (1990) $FMR = 803.9W^{0.75}$		
B.W. (kg)	Consumption (kg)		B.W. (kg)	Consumption (kg)		B.W. (kg)	Consumption (kg)	
RCH	1.34	1.79	*RCH*	1.34	1.79	*RCH*	1.34	1.79
3,500	65	87	3,500	183	245	3,500	130	174
3,800	68	91	3,800	196	261	3,800	139	185
5,000	78	105	5,000	243	324	5,000	170	228
6,900	93	124	6,900	312	417	6,900	217	290
7,500	97	129	7,500	333	445	7,500	231	309
8,100	101	135	8,100	354	473	8,100	245	327
10,000	113	150	10,000	417	558	10,000	287	383
15,000	139	186	15,000	573	766	15,000	389	519
20,000	162	216	20,000	718	959	20,000	482	644
25,000	182	243	25,000	855	1,143	25,000	570	761
30,000	200	267	30,000	987	1,318	30,000	654	873
30,400	201	269	30,400	997	1,332	30,400	660	882
35,000	217	290	35,000	1,113	1,487	35,000	734	980
40,000	233	311	40,000	1,236	1,651	40,000	811	1,083
45,000	247	331	45,000	1,355	1,810	45,000	886	1,183
50,000	262	349	50,000	1,472	1,966	50,000	959	1,281
55,600	276	369	55,600	1,599	2,137	55,600	1,038	1,387
60,000	288	384	60,000	1,698	2,268	60,000	1,099	1,468
65,000	300	401	65,000	1,808	2,415	65,000	1,167	1,559
70,000	312	417	70,000	1,916	2,559	70,000	1,234	1,648
75,000	323	432	75,000	2,022	2,701	75,000	1,299	1,736
80,000	335	447	80,000	2,127	2,841	80,000	1,364	1,822
85,000	345	461	85,000	2,230	2,979	85,000	1,427	1,907
90,000	356	475	90,000	2,332	3,115	90,000	1,490	1,990
95,000	366	489	95,000	2,433	3,250	95,000	1,552	2,073
100,000	376	502	100,000	2,533	3,383	100,000	1,612	2,154

Table 6

The seasonal prey consumption for all fin whales in the research area based on three methods

Area	Year	Abundance (inds.)	Prey consumption (million tons)		
			Equation 2	Equation 3	Equation 4
III East	2007/08	956	0.03- 0.04	0.18- 0.25	0.12- 0.16
IV	2007/08	1,654	0.05- 0.07	0.32- 0.42	0.21- 0.28
V	2008/09	10,056	0.33- 0.45	1.93- 2.58	1.25- 1.67
VI West	2008/09	4,925	0.16- 0.22	0.95- 1.26	0.61- 0.82
Total		17,591	0.54-0.78	3.38-4.51	2.19-2.93

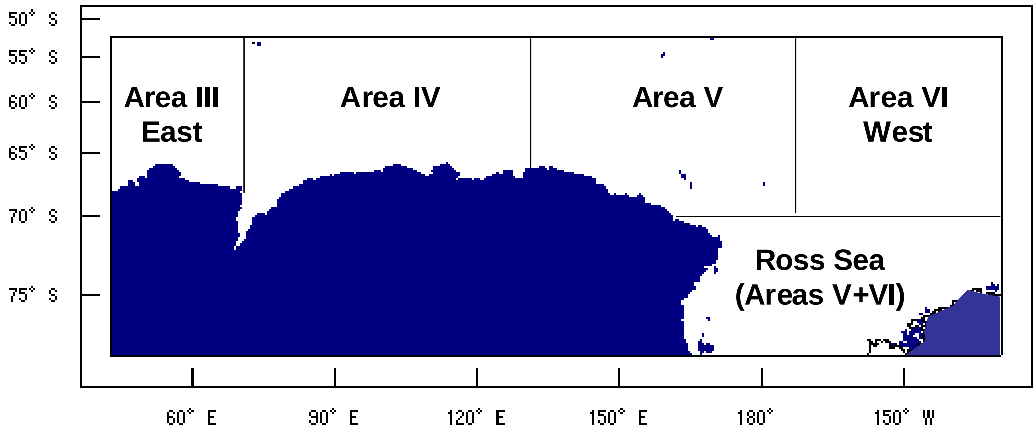

Fig.1. Research area in the Antarctic

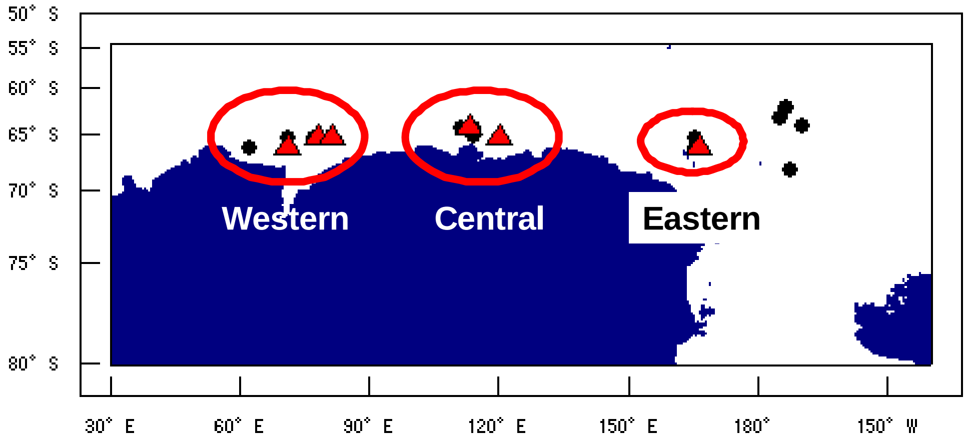

Fig.2. The position of fin whales sampled and Antarctic minke whales sampled in this study.
(●: Fin whales, ▲: Antarctic minke whales)

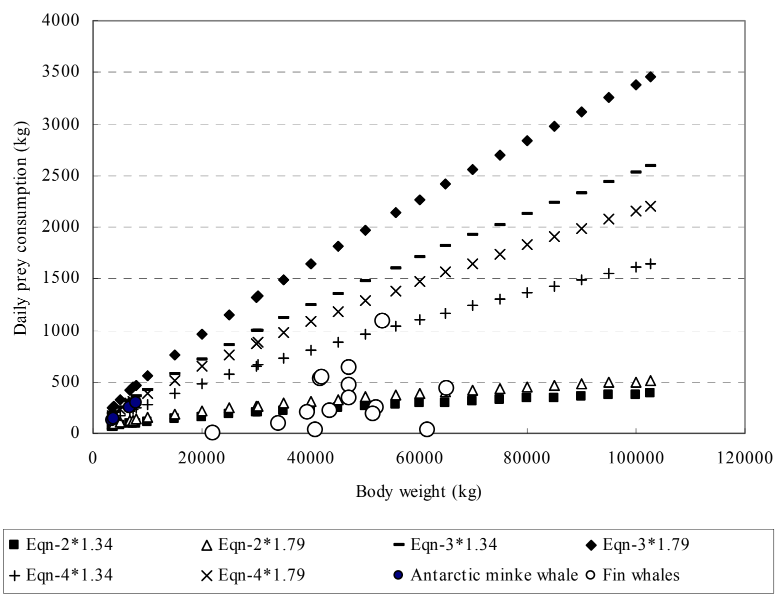

Fig.3. The relationship between body weight and daily prey consumption in each equation and *RCH*.
(○: Stomach contents weight observed of fin whales, ●: estimates consumption of Antarctic minke whales)

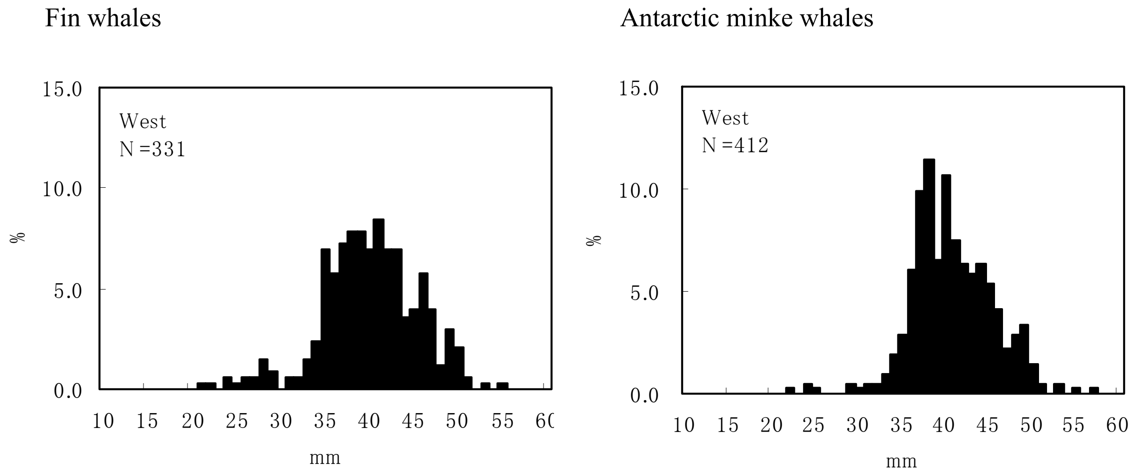

Fig.4. The length of frequency distributions of *Euphausia superba* for fin whales (Left: N=6) and Antarctic minke whales (Right: N=5) sampled on the western side.

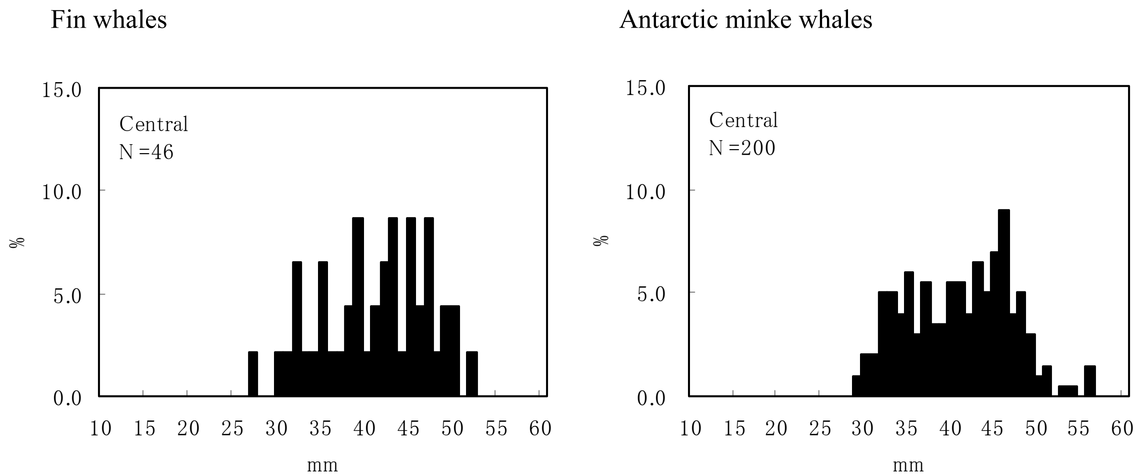

Fig.5. The length of frequency distributions of *Euphausia superba* for fin whales (Left: N=2) and Antarctic minke whales (Right: N=2) sampled on the central side.

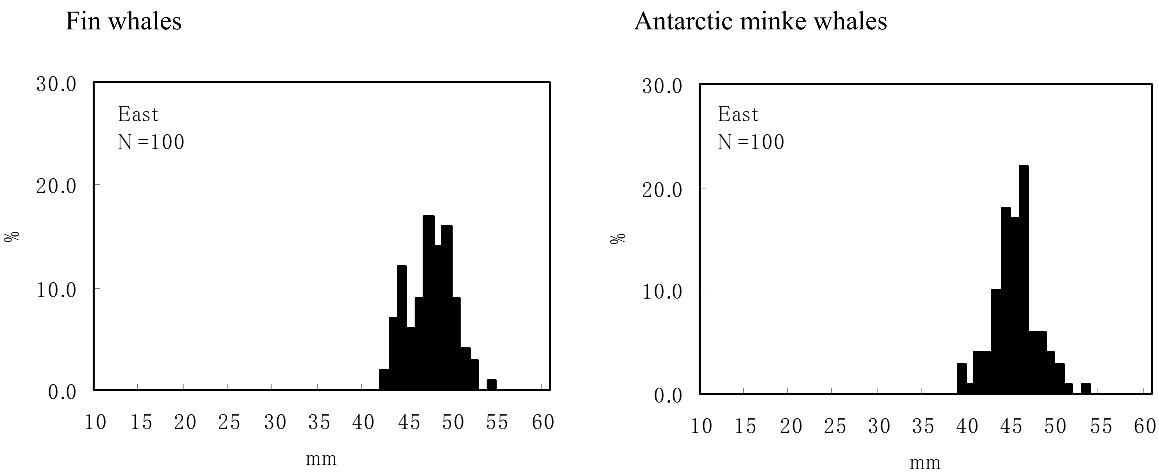

Fig.6. The length of frequency distributions of *Euphausia superba* for fin whales (Left: N=1) and Antarctic minke whales (Right: N=1) sampled on the eastern side.

Appendix 1. The summary table of data on fin whales and Antarctic minke whales in this study.

Sector: See to Fig. 2 in this paper.

SCW: Total of forestomach and fundus stomach contents weight (kg)

Body length of krill: The data on body length of *Euphausia superba* ingested by whales was used in this study.

*: A part of the body of this whale was torn off and sank into the sea while it was being pulled onboard the *NM*.

●: I measured the body length of krill in the stomach contents.

N.D.: No data

Fin whale （N=17）

Year	No	Catch date	Area	Sighting Time	Sighting position						Catching position						BL(m)	BW(t)	Sex	Sector	1+2nd SCW	Stomach Freshness	Body length of *E. superba*
2005/06	F001	02/03/2006	IV	10.11	65	50	S	71	28	E	65	44	S	71	38	E	19.17	N.D.	M	Western	254.9	2	●
2005/06	F002	02/08/2006	IV	6.12	65	55	S	77	56	E	65	54	S	78	6	E	20.05	53.48	F	Western	1,084.7	2	●
2005/06	F003	02/09/2006	IV	6.13	65	52	S	78	4	E	65	48	S	78	7	E	19.47	52.05	F	Western	246.6	2	●
2005/06	F004	02/10/2006	IV	7.42	65	42	S	78	26	E	65	37	S	78	13	E	18.73	41.87	M	Western	524.5	3	●
2005/06	F005	02/13/2006	IV	6.42	65	25	S	81	49	E	65	22	S	81	60	E	19.14	47.28	M	Western	633.7	1	●
2005/06	F006	02/14/2006	IV	7.43	65	10	S	81	45	E	65	10	S	81	59	E	19.15	47.04	F	Western	468.9	3	●
2005/06	F007	03/07/2006	IV	14.48	64	32	S	111	60	E	64	34	S	111	51	E	20.22	61.52	F		25.9	N.D.	N.D.
2005/06	F008	03/09/2006	IV	9.14	65	2	S	114	14	E	64	53	S	114	6	E	18.22	41.06	F	Central	29.4	3	●
2005/06	F009	03/10/2006	IV	6.38	64	57	S	114	15	E	64	48	S	114	14	E	18.3	42.27	M		545.8	4	N.D.
2005/06	F010	03/13/2006	IV	9.50	65	34	S	120	15	E	65	36	S	120	30	E	19.35	47.24	F	Central	333.9	3	●
2006/07	F001	01/03/2007	V	9.51	64	4	S	170	38	W	63	53	S	170	44	W	N.D.	N.D.	*		N.D.	N.D.	N.D.
2006/07	F002	01/05/2007	V	8.38	62	34	S	174	18	W	62	35	S	174	17	W	20.67	51.62	M		183.8	1	N.D.
2006/07	F003	02/02/2007	V	12.36	68	51	S	173	42	W	68	46	S	173	41	W	21.15	65.02	F		437.0	3	N.D.
2008/09	F001	03/13/2009	V	6.36	65	40	S	165	23	E	65	38	S	165	8	E	14.79	22.26	F	Eastern	0.0	2	●
2009/10	F001	02/03/2010	III	5.10	66	0	S	62	18	E	66	8	S	62	33	E	17.61	34.20	M		90.6	N.D.	N.D.
2010/11	F001	01/07/2011	V	7.42	63	23	S	175	42	W	63	28	S	175	40	W	19.05	39.63	M		194.0	3	N.D.
2010/11	F002	01/20/2011	V	7.58	66	39	S	165	47	E	66	39	S	165	32	E	18.99	43.78	M		224.7	2	N.D.

Antarctic minke whale （N=8）

Year	No	Catch date	Area	Sighting Time	Sighting position						Catching position						BL(m)	BW(t)	Sex	Sector	1+2nd SCW	Stomach Freshness	Body length of *E. superba*
2005/06	AM453	02/03/2006	IV	6.25	66	18	S	71	5	E	66	21	S	71	1	E	9.35	N.D.	M	Western	18.15	1	●
2005/06	AM507	02/08/2006	IV	6.14	66	0	S	78	9	E	65	60	S	78	7	E	8.67	N.D.	M	Western	135.4	1	●
2005/06	AM513	02/10/2006	IV	6.53	65	42	S	78	25	E	65	43	S	78	30	E	7.62	N.D.	F	Western	75.65	2	●
2005/06	AM547	02/13/2006	IV	6.42	65	18	S	81	24	E	65	16	S	81	16	E	9.15	N.D.	F	Western	240.45	1	●
2005/06	AM550	02/14/2006	IV	6.27	65	17	S	81	52	E	65	18	S	81	48	E	8.32	N.D.	M	Western	123.2	1	●
2005/06	AM801	03/09/2006	IV	6.33	64	59	S	113	21	E	65	3	S	113	25	E	8.27	N.D.	M	Central	82.45	1	●
2005/06	AM828	03/13/2006	IV	7.59	65	28	S	120	7	E	65	32	S	119	45	E	6.16	N.D.	M	Central	40.15	1	●
2008/09	AM661	03/15/2009	V	8.53	65	12	S	163	42	E	65	12	S	163	50	E	6.34	3.75	M	Eastern	19.24	1	●