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Cruise report of the second phase of the Japanese Whale Research Program under Special Permit in the Western North Pacific (JARPN II) in 2007 - Coastal component off Sanriku.

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ABSTRACT
The fourth survey of the JARPN II coastal component was conducted from 16 April to 31 May in 2007, off Sanriku district, northeastern Japan (middle part of the sub-area 7), using four small-type whaling catcher boats and one echo sounder trawl survey vessel. In the survey, sampling of common minke whales was conducted in coastal waters mainly within 30 nautical miles from Ayukawa port in the Sanriku district, and all animals collected were landed on the JARPN II research station established by the port for biological examination. During the survey, a total of 7793.7 nautical miles (716.5 hours) was surveyed for whale sampling, the 166 schools (171 individuals) of common minke whales were detected, and 57 animals were caught. Average body length of the animals was 6.25m (SD: 1.30, *n*=21) for males and 5.67m (SD: 1.16, *n*=36) for females. Dominant prey species found from forestomach of animals were Japanese sand lance (*Ammodytes personatus*) and Japanese anchovy (*Engraulis japonicus*) throughout survey period. Krill (*Euphausia pacifica*) was observed from only one individual. Seasonal pattern of the dominant prey species through the survey period was different from the past three coastal surveys off Sanriku. These results indicate that feeding habit of common minke whales in coastal waters off Sanriku changes year by year.

KEYWORDS: COMMON MINKE WHALE; NORTH PACIFIC; COASTAL WATERS OF JAPAN; FOOD/PREY; ECOSYSTEM; SCIENTIFIC PERMITS.

INTRODUCTION

After the two-year feasibility study in 2000-2001, the full-scale survey of the second phase of the Japanese Whale Research Program under Special Permit in the Western North Pacific (JARPN II) was started in 2002. The purpose of the program is, i) to evaluate the feeding ecology and ecosystem studies, involving prey consumption by cetaceans, prey preferences of cetaceans and ecosystem studies, ii) to monitor environmental pollutants in cetaceans and the marine ecosystem and iii) to elucidate the stock structure of whales (Government of Japan, 2002a).

The JARPN (1994-1999) and the JARPN II feasibility studies (2000-2001) revealed that common minke whales are widely distributed from offshore waters to coastal waters and feed on various prey species such as Japanese anchovy, Pacific saury, and walleye pollock (Government of Japan, 2002b; Tamura and Fujise, 2002). The coastal waters of Japan are also very important fishing ground. Thus, it was thought that the coastal waters are also very important research area for the full-scale JARPN II program. However, the *Nisshin Maru* research vessels can not be operated in the near shore areas, because of their movement restrictions from shallow water depth, and many fishing gears and boats. Furthermore, the vessels can not work from late autumn to early spring because of their practical availability. In order to cover the temporal and spatial gap of the vessels, sampling of

common minke whales in the coastal waters using small-type whaling catcher boats was planned.

In the original JARPN II plan, the coastal component was presented as the two-year feasibility study to examine the logistic aspects of the methodology (Government of Japan, 2002a). First feasibility survey was carried out in the coastal waters off Kushiro in fall 2002 (Kishiro, *et al*., 2003) and then the second feasibility survey was conducted in the coastal waters off Sanriku district in spring 2003 (Yoshida, *et al*., 2004). In each of the surveys, 50 common minke whales were caught. From detailed examination of logistic aspects in the surveys, it was concluded that no substantial problem occurred and that the coastal survey could be continued as a component of the JARPN II using same kind of vessels (small-type whaling catcher boats) and methodology (Government of Japan, 2004b, Kato, *et al*., 2004). However, re-calculation of required sample size from the survey data suggested that the size should be modified to be at least 60 individuals in each area/season (Tamura, *et al*., 2004), and from the possible geographical and/or temporal variations of prey consumption of the whales, the coastal surveys thought to be needed on a yearly bases in each local area (Government of Japan, 2004a). The revised survey off Sanriku was carried out in spring 2005 (Yoshida, *et al*., 2006) and 2006 (Goto, *et al*., 2007).

In the present paper, we show results of the fourth survey carried out in coastal waters off the Sanriku district, Japan, from 16 April to 31 May in 2007. This survey was authorized by the Government of Japan in compliance with Article VIII of the International Convention for the Regulation of Whaling. The Institute of Cetacean Research (ICR) planned and conducted the survey cooperated with National Research Institute of Far Seas Fisheries, Tokyo University of Marine Science and Technology and Miyagi Prefecture Fisheries Research and Development Center.

MATERIALS AND METHODS

Research area

Research area was set in the same waters where the previous JARPN II coastal surveys off the Sanriku district were conducted (Yoshida *et. al*, 2004; 2006; Goto *et al*., 2007). The district occupies northeastern part of the Japanese main island, Honshu (see, Fig. 1). In coastal waters off the Sanriku district, common minke whales were taken by the past land-based coastal whaling (Miyashita and Hatanaka, 1997). The waters have been also very important fishing grounds. So, the waters were thought to be suitable for the research area of the JARPN II, and thus the coastal surveys were conducted in this area. The present research area was also set in the same waters: within 50 nautical miles (mainly 30 n. miles) from the Ayukawa port in the Sanriku district (Fig. 1). The survey area is included in the middle part of the sub-area 7 established by the IWC (1994).

Research vessels and station

Whale sampling survey

Four small-type whaling catcher boats were used as sampling vessels: *Taisho Maru* No. 28 (hereinafter referred as 28T; 47.3GT), *Koei Maru* No. 75 (75K; 46.0GT), *Katsu Maru* No.7 (7K; 32.0GT), and *Sumitomo Maru* No.31 (31S; 32.0GT). The whale sampling survey was conducted in a period from 16 April to 31 May, 2007. All the animals sampled were landed on the JARPN II research station established by the Ayukawa port for biological examination.

Prey species survey

The *Takuyo Maru* (TAK, 120.0GT), the trawler-type research vessel, conducted the prey species survey in research area set off northeast coast of Honshu from 9 to 27 April. The distribution and abundance of the prey species were investigated with the quantitative echo sounder (EK 500 and ER 60) on board TAK. Acoustic data were acquired with operating frequency at 38, 120 and 200 kHz. Species/size compositions of echo signs were identified by targeting mid-water trawling. Detail of the prey species surveys are shown in Appendix 1. The research vessel TAK also carried out oceanographic observation using CTD and EPCS. Detail of the oceanographic observation are shown in Appendix 2.

Sighting and sampling methods

Sighting and sampling methods by whale sampling vessels were almost same in the past three coastal surveys conducted off Ayukawa in 2003, 2005 and 2006 (Yoshida *et al*.: 2004; 2006, Goto *et al*.: 2007). The research head office was placed in the research station and operated the sampling vessels during the survey. In order to avoid concentration of sampling effort, research area was divided into 3 small areas. The office determined searching area and routes of sampling vessels everyday considering weather conditions, whale distribution and information on coastal fisheries.

A researcher was on board each of four sampling vessels, and recorded sighting and sampling information, e.g., coordinates and time of common minke whales sighting and sampling made, weather conditions, and vessel activity. Sighting information was also recorded for other baleen whales and sperm whales. Searching activity was conducted from top barrel and upper bridge by crews and researchers. All common minke whales sighted were targeted for sampling, except cow-calf pair. When a school consisted of plural animals, an individual was selected randomly from the school and then caught. Once the vessel sampled a whale, she returned to the Ayukawa port as soon as possible, to transport the animal to the research station. During the return cruise, even if common minke whales were sighted, sampling was not conducted. At the port, animals taken were lift up from the vessels by a crane, using a wire net and then carried to the station by a freight trailer. At that time, body weight was measured with the truck scale.

Biological research for common minke whales collected
All the animals collected were examined biologically by researchers at the research station. Research items of the biological examination are summarized in Table 4. These items are related to studies on feeding ecology, stock structure, life history and pollutions.

RESULTS

Searching effort made by sampling vessels
Cruise tracks made by sampling vessels (28T, 75K, 7K and 31S) during the present survey are shown in Fig. 2. The sampling vessels tried to cover research areas widely within 30 n. miles from Ayukawa port. In offshore waters, however, searching activity was low because of changeable weather condition and bigger waves for small sampling vessels. Consequently, searching effort was concentrated in Sendai Bay. Searching distance and time made by four sampling vessels are listed in Table 1. Here, searching distance and time are defined as distance and time recorded under searching activity conducted from top barrel of vessels. Total searching distance and time made by the four vessels were 7793.7 n. miles and 716.5 hours, respectively.

Common minke whale sightings made by sampling vessels
Sighting positions of common minke whale schools made by the sampling vessels are shown in Fig. 3. All of common minke whale sightings were recorded in middle part of Sendai Bay. As shown in Table 2, a total of 166 schools (171 individuals) of common minke whales was sighted. These were 149 primary sightings (153 animals) and 17 secondary sightings (18 animals). Of 166 schools sighted, only 5 schools consisted of 2 individuals and others were solitary animals. No cow-calf pairs nor other large whale species were sighted.

Table 3 shows density index (SPUE: number of primary school sightings per one hour searching; DI: number of primary school sightings per 100 n. miles searching) of common minke whales recorded by the sampling vessels. Both SPUE and DI are highest during first half of May through the research period.

Sampling of common minke whales
A total of 57 common minke whales were taken for biological examination. In the sampling process, one common minke whale was struck and lost. Sighting positions of sampled individuals are shown in Fig. 4.

Sex ratio, body length and weight of animals caught
Research items of biological examination are summarized in Table 4, with number of data and

samples obtained. The collected 57 animals consisted of 21 males and 36 females. Sex ratio of males to all animals was 0.37.

Average body length was 6.25m (max=8.06, min=4.24, SD: 1.30) for males and 5.67m (max=8.80, min=4.05, SD=1.16) for females, respectively (Table 5). Frequency of body length of common minke whale by sex was shown in Fig. 5. Average body weight was 3.08 tons (max=5.50, min=1.05, SD=1.50) for males and 2.52 tons (max=8.35, min=0.91, SD=1.63) for females (Table 6). Average body length of female was gradually increased during survey period from 5.46m in the first period to 5.91m in third period but marked difference was not detected for male.

Composition of sexual maturity of animals collected is listed in Table 7. In males, 9 of 20 animals were sexually mature (45.0%), and 7 of 36 females attained sexual maturity (19.4%). Six from seven mature females were pregnant and one female was pregnant and lactating simultaneously.

Prey species of common minke whale found from forestomach

Following the same methods used in the JARPN II feasibility survey conducted in 2001 (Fujise, *et al*., 2002), stomach contents were weighted to the nearest 0.1 kg, by each of four chamber, in both cases of including and excluding liquid contents. Then, small sample of forestomach contents was collected and frozen for laboratory analysis.

Forestomach contents found from common minke whales during the present survey are listed in Table 8. Dominant prey species were adult sand lance (*Ammodytes personatus*) (69.4%, 34 from 49 animals) and Japanese anchovy (40.8%, 20 from 49 animals). Sand lance and Japanese anchovy were detected throughout the survey period. Krill (*Euphausia pacifica)* was recorded from only one animal in the third period.

The maximum weight of forestomach contents including liquid was 65.2kg, of which consisted Japanese anchovy. This individual was female with body length of 7.91m and body weight of 4.93 tons. Forestomach contents weight was 1.32% of her body weight.

By-products of the whales

After biological examination, all the animals were processed according to the International Convention for Regulation of Whaling, Article VIII. Total weight of productions including meat and blubber was 78.3 tons.

DISCUSSION

The present survey was the fourth coastal survey carried out in coastal waters off Sanriku district. During the survey period, low atmospheric pressure often disturbed the research activities. Furthermore, changeable weather condition and bigger waves obstructed searching activities of sampling vessels in offshore waters. Nevertheless, almost all of planned sample size was collected in Sendai Bay, where water depth is less than 100m and *Nisshin Maru* research vessels can not operate.

Dominant prey species of common minke whale found from forestomach were Japanese sand lance and Japanese anchovy throughout survey period. Krill was found in only one individual. This seasonal pattern of dominant prey species was different from past three coastal surveys off Sanriku. In the 2003 coastal survey off Sanriku, dominant species changed with time (Yoshida, *et al*. 2004): krill were dominant in the first period (74.8%), then the occurrence frequency reduced with time, and in the third period sand lance were found most frequently (92.2%). On the other hand, dominant prey species was Japanese sand lance (45.0%) in the 2005 coastal survey off Sanriku. Sand lance was detected throughout the survey. Krill and Japanese anchovy were also found, but their frequency was much lower (6.7%) (Yoshida *et al*., 2006). In 2006, sand lance and Japanese anchovy were dominant prey species but Japanese anchovy appeared only in later period of the survey. These results indicate that feeding habit of common minke whales in coastal waters off Sanriku changes year by year, probably from environmental factors, e.g., oceanographic conditions or prey species

distribution.

Sea surface water temperature during last winter was higher than ordinal years and some Japanese anchovy overwintered in the bottom of Sendai Bay (Nagashima, personal communication). High surface water temperature, which was 1-2℃ higher than last year, was also recorded by prey species survey conducted from 9 to 27 April and Japanese anchovy was detected by eco-sounder throughout survey period (see Appendix 1). This suggests that diet composition of common minke whales in the Sendai Bay reflects abundance of prey species. These results will contribute to elucidate prey preference of common minke whales.

From the present survey, we could obtain valuable information including feeding ecology of minke whales. To evaluate more precise values on food consumption of minke whales and to obtain more information on interaction between the whales and coastal fisheries, continuation of studies are needed.

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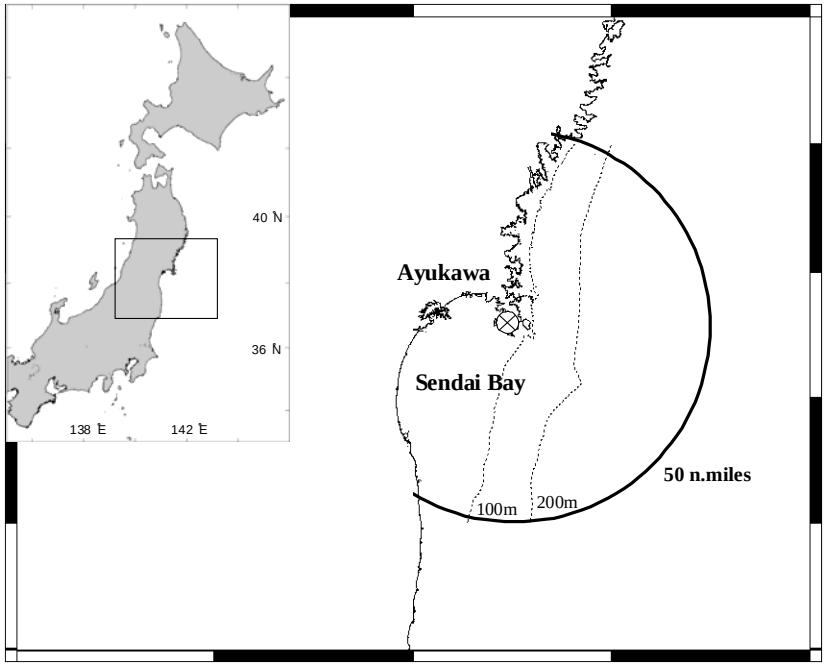

Fig . 1. Research area of the 2007 JARPNII coastal survey off Sanriku.

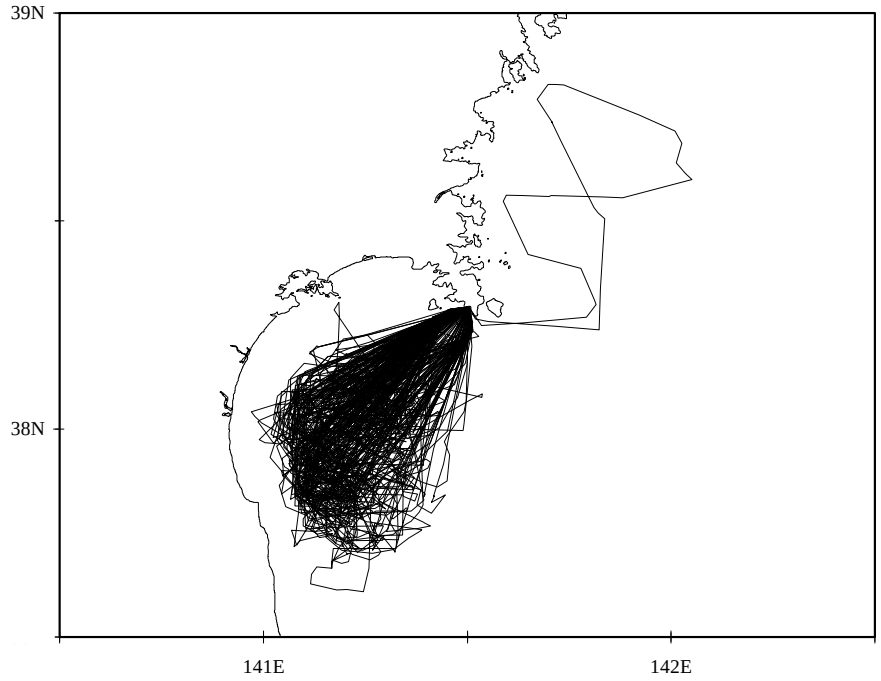

Fig. 2. Cruise trucks made by four sampling vessels in the 2007 JARPNII coastal survey off Sanriku.

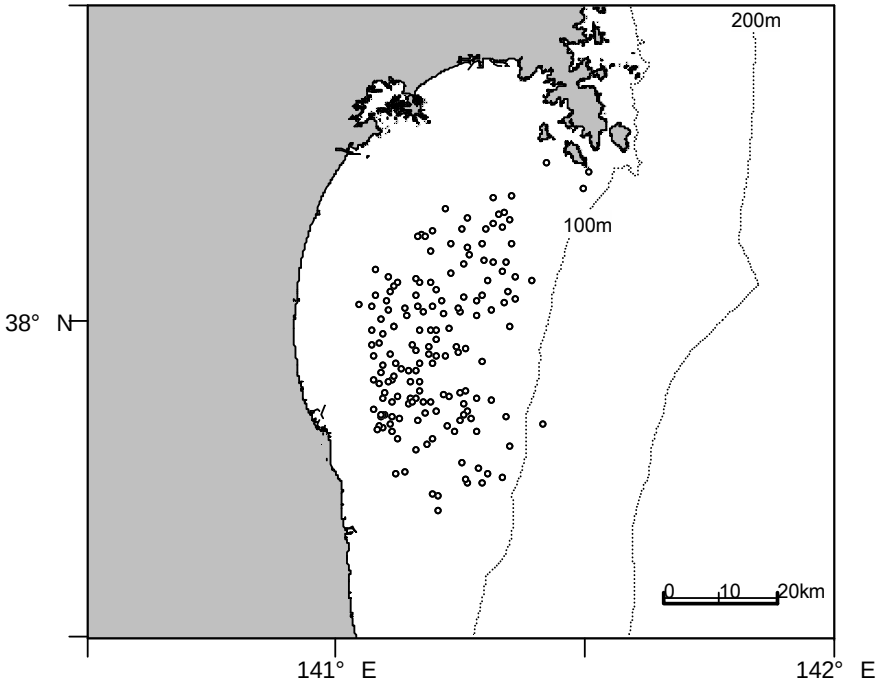

Fig. 3. Sighting position of common minke whales made by sampling vessels in the 2007 JARPNII coastal survey off Sanriku.

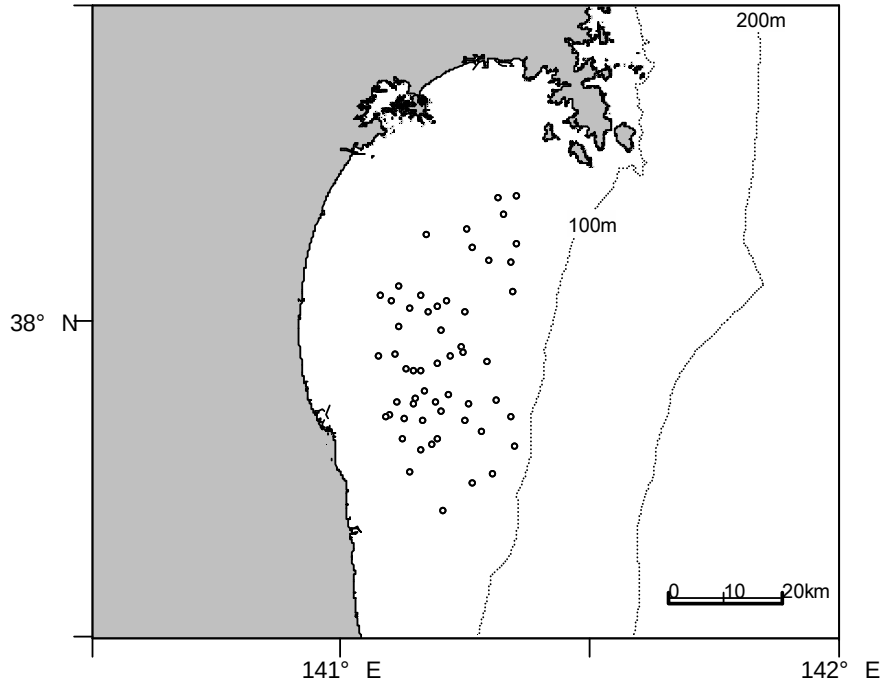

Fig. 4. Sighting position of sampled common minke during the 2007 JARPNII coastal survey off Sanriku.

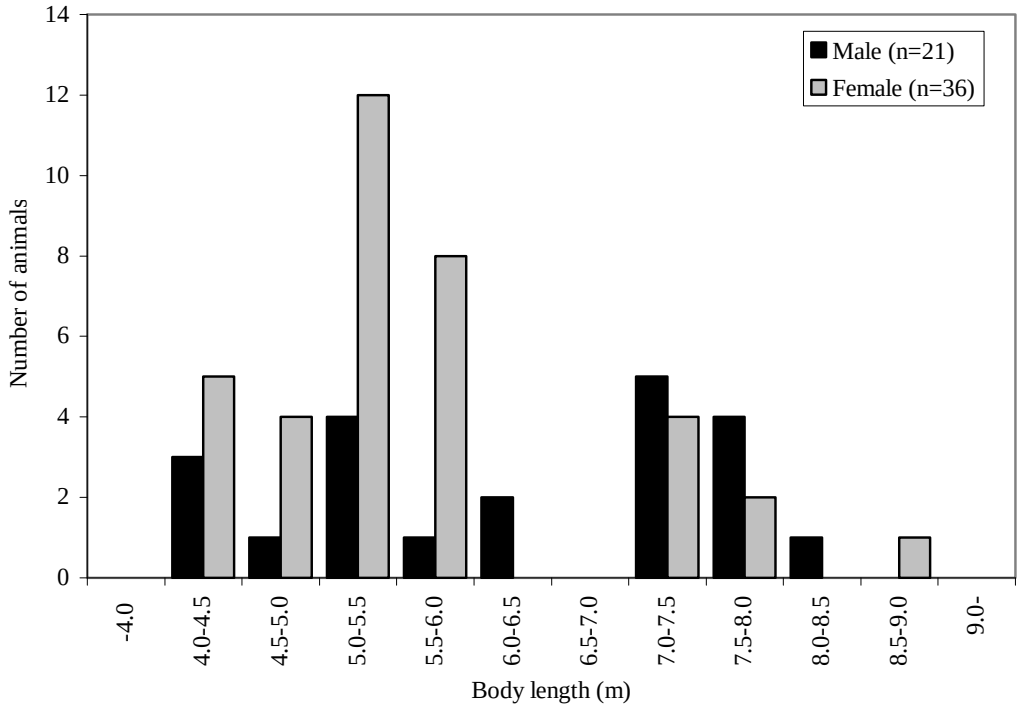

Fig . 5. Frequency of body length of common minke whales taken in the 2007 JARPNII coastal survey by sex.

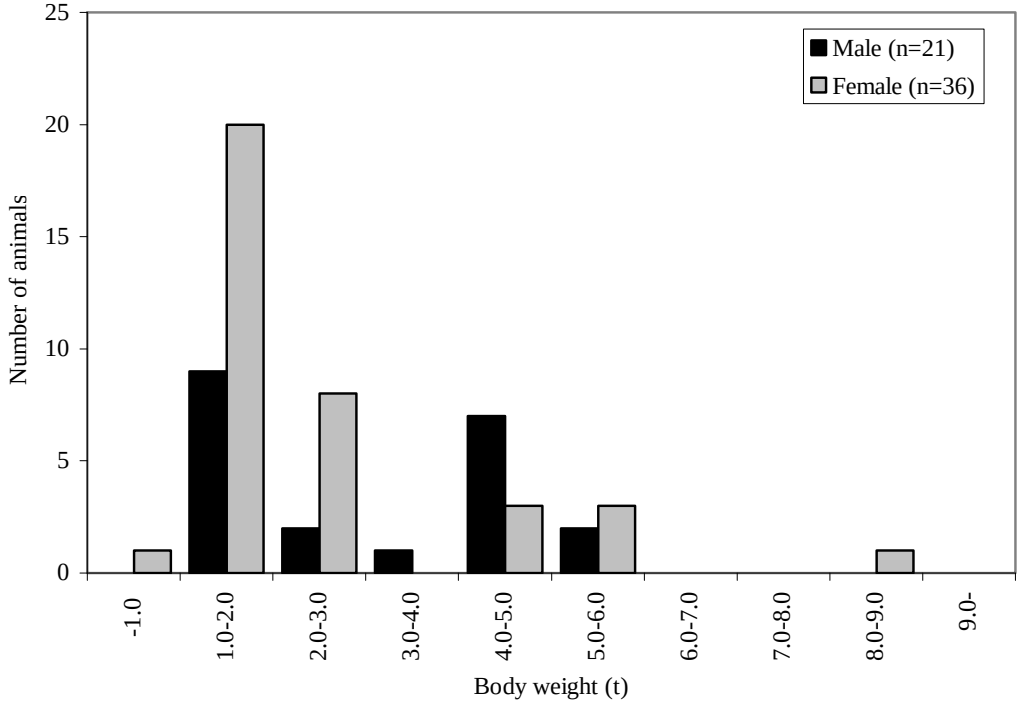

Fig .6. Frequency of body weight of common minke whales taken in the 2007 JARPNII coastal survey by sex.

Table 1. Searching days, hours, distances by four sampling vessels in the 2007 JARPN II coastal surveys off Sanriku.

Period		Sampling vessels*				Total
		28T	75K	07K	31S	
First period	Days	9	9	9	9	36
(16-30 April)	Hours	52.0	55.0	56.0	55.1	218.1
	Distances (n. mile)	588.6	590.4	593.1	598.7	2370.9
Second period	Days	9	9	9	9	36
(1-15 May)	Hours	55.2	53.7	61.7	53.0	223.6
	Distances (n. mile)	630.9	580.4	664.0	589.2	2464.5
Third period	Days	11	11	11	11	44
(16-31 May)	Hours	71.5	69.6	73.0	60.8	274.9
	Distances (n. mile)	805.2	724.6	759.1	669.5	2958.3
Total	Days	29	29	29	29	116
	Hours	178.7	178.3	190.7	168.8	716.5
	Distances (n. mile)	2024.7	1895.4	2016.2	1857.5	7793.7

*: 28T; *Taisho Maru* No.28, 75K; *Koei Maru* No.75, 07K; *Katsu Maru* No.7, 31S; *Sumitomo Maru* No.31.

Table 2. List of cetacean species and number of sightings made by four sampling vessels in the 2007 JARPN II coastal surveys off Sanriku.

Period	Species	Primary		Secondary		Total	
		Sch.	Ind.	Sch.	Ind.	Sch.	Ind.
First period	Common minke whale	41	42	6	6	47	48
(16-30 April)	Like minke whale	7	7	0	0	7	7
Second period	Common minke whale	51	52	2	2	53	54
(1-15 May)	Like minke whale	6	6	0	0	6	6
Third period	Common minke whale	57	59	9	10	66	69
(16-31 May)	Like minke whale	10	10	0	0	10	10
	Unidentified whale	1	2	0	0	1	2
Total	Common minke whale	149	153	17	18	166	171
	Like minke whale	23	23	0	0	23	23

Unidentified whale	1	2	0	0	1	2

Table 3. Density index of common minke whales by sampling vessels in the 2007 JARPN II coastal survey off Sanriku.

Period	SPUE[*1]	DI[*2]
First period (16-30 April)	0.19	1.77
Second period (1-15 May)	0.23	2.11
Third period (16-31 May)	0.21	1.99
Total	0.21	1.96

[*1]: No. of primary school sightings per 1 hour searching.

[*2]: No. of primary school sightings per 100 n. miles searching.

Table 4. Summary of biological data and samples collected during the 2007 JARPN II coastal survey off Sanriku.

Samples and data	Number of animals		
	Male	Female	Total
Detailed measurements of blubber thickness (11 points)			
Body length and sex	21	36	57
External body proportion	21	36	57
Photographic record and external character	21	36	57
Diatom film record	21	36	57
Body scar record	21	36	57
Measurements of blubber thickness (5 points)	21	36	57
Detailed measurements of blubber thickness (11 points)	2	0	2
Body weight	21	36	57
Body weight by parts	2	0	2
Skin tissues for DNA study	21	36	57
Muscle, liver, kidney, spleen, blubber, heart and ventral groove for various analysis	21	36	57
Urine for various analysis	8	0	8
Muscle, liver, kidney, and blubber for heavy metal analysis	21	36	57
Muscle, liver, kidney, and blubber for organochlorine analysis	21	36	57
Collection of blood plasma	20	34	54
Muscle and vertebra for lipid analysis	2	0	2
Mammary grand; lactation status, measurement and histological sample	-	36	36
Uterine horn; measurements and endometrium sample	-	36	36
Collection of Ovary	-	36	36
Photographic record of fetus	2	3	6*
Foetal length and weight	2	3	6*
External measurement of fetus	2	3	5
Muscle, liver, kidney, heart, blubber and skin tissues of fetus	2	3	5
Collection of fetus	0	0	1*

Testis and epididymis; weight and histological sample	21	-	21
Stomach contents, convenient record	21	36	57
Volume and weight of stomach content in each compartment	21	36	57
Observation of marine debris in stomach	21	36	57
Stomach contents for feeding study	20	30	50
Record of external parasites	21	36	57
Earplug for age determination	21	36	57
Tympanic bulla for age determination	21	36	57
Eye lens for age determination	21	36	57
Largest baleen plate for morphologic study and age determination	21	36	57
Baleen plate measurements (length and breadth)	21	35	56
Photographic record of baleen plate series	21	36	57
Length of baleen series	21	36	57
Vertebral epiphyses sample	21	36	57
Number of ribs	21	36	57
Skull measurement (length and breadth)	21	36	57

*: including a fetus of sex unidentified.

Table 5. Statistics of body length (m) of common minke whales collected during the 2007 JARPN II coastal survey off Sanriku.

Period	Male					Female				
	mean	S.D.	Min.	Max.	n	mean	S.D.	Min.	Max.	n
First period (16-30 April)	6.26	0.95	5.09	7.41	3	5.46	1.15	4.33	7.99	7
Second period (1-15 May)	6.28	1.30	4.49	7.77	8	5.49	1.06	4.40	7.91	13
Third period (16-31 May)	6.23	1.40	4.24	8.06	10	5.91	1.18	4.05	8.80	16
Total	6.25	1.30	4.24	8.06	21	5.67	1.16	4.05	8.80	36

Table 6. Statistics of body weight (tons) of common minke whales collected during the 2007 JARPN II coastal survey off Sanriku.

Period	Male					Female				
	mean	S.D.	Min.	Max.	n	mean	S.D.	Min.	Max.	n
First period (16-30 April)	2.97	1.16	1.66	4.48	3	2.35	1.52	1.17	5.94	7
Second period (1-15 May)	3.13	1.58	1.11	5.50	8	2.18	1.20	1.18	4.93	13
Third period (16-31 May)	3.07	1.53	1.05	5.25	10	2.88	1.90	0.91	8.35	16
Total	3.08	1.50	1.05	5.50	21	2.52	1.63	0.91	8.35	36

Table 7. Composition of sex and sexual maturity status of common minke whales collected by the 2007 JARPN II coastal survey off Sanriku.

Period	Male					Female					
	Im	M	Uk	Total	Maturity (%)	Imm.	R	P	P&L	Total	Maturity (%)
First period (16-30 April)	2	1	0	3	0.33	6	0	1	0	7	0.14
Second period (1-15 May)	4	4	0	8	0.50	11	1	0	1	13	0.15
Third period (16-31 May)	5	4	1	10	0.44	12	0	4	0	16	0.25
Total	11	9	1	21	0.45	29	1	5	1	36	0.19

Im: Immature, M: Mature, R: Resting, P: Pregnant, P&L: Pregnant and lactating

Table 8. Prey species found in forestomach of common minke whales collected by the 2007 JARPN II coastal survey off Sanriku.

Period	Sample size	Prey species				
		Sand lance (adult)	Japanese anchovy	Sand lance (adult) and Japanese anchovy	Sand lance (adult) and Krill	None
First period (16-30 April)	10	6	3	1	0	0
	(%)	60.0	30.0	10.0	0.0	0.0
Second period (1-15 May)	19	9	8	2	0	0
	(%)	47.4	42.1	10.5	0.0	0.0
Third period (16-31 May)	20	12	3	3	1	1
	(%)	60.0	15.0	15.0	5.0	5.0
Total	49*	27	14	6	1	1
	(%)	55.1	28.6	12.2	2.0	2.0

*: excluding animals with broken stomach by harpoon.

Appendix 1

2007 coastal prey species survey of JARPN II off Sanriku

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ABSTRACT
A prey species survey was conducted in the coastal region off Sanriku, northeastern Japan, concurrently with the coastal sampling survey for common minke whale during spring 2007 as a part of JARPN II study. The objective of concurrent surveys was to estimate the prey preference (selection) of common minke whale. While the sampling survey for common minke whale was conducted within 30 nautical miles (max 50 nautical miles) from Ayukawa port in Miyagi prefecture, the prey species survey was conducted in wider area at depths between 20 m and 200 m from 37º 40' N to 38º 40' N off Sanriku, northeastern Japan. The survey area was divided into 7 blocks with depth and latitude. The distribution and abundance of the prey species were investigated with the quantitative echosounder (EK 500) on board Takuyo Maru (120 GT) steaming at 9 – 10 knots along the track lines during daytime. Acoustic data were acquired with operating frequency at 38, 120 and 200 kHz. Species/size compositions of echo signs were identified by targeting mid-water trawlings. As well as the last year, the water temperature was high. Therefore, many schools of anchovy were distributed. Echo signs identified as adult sand lance (> 10 cm in standard length) occurred at depths between 20 m and 60 m on Block B and C. Many echo signs identified as juvenile sand lance occurred as smaller patches in the mid-layer in the shallower area. Krill was frequently found at depths deeper than 70 m.

INTRODUCTION
The goal of JARPN II is to contribute to the conservation and sustainable use of marine living resources including whales in the western North Pacific, especially within Japan's EEZ (Government of Japan, 2002). The priority is put on feeding ecology and ecosystem studies, involving studies of prey consumption by cetaceans, prey preference (selection) of cetaceans and ecosystem modeling. As it is difficult to cover the coastal area, especially in spring and autumn, by the *Nisshin Maru*, the full-scale JARPN II has a new coastal component, that is, the sampling survey for common minke whale by small-type whaling catcher boats. As in 2003, 2005, and 2006 surveys (Kawahara *et al*., 2004; Yonezaki *et al*., 2006, 2007), a prey species survey was conducted in the coastal region off Sanriku northeastern Japan, concurrently with the coastal sampling survey for common minke whale during spring 2007. In this document, the results of the 2007 prey species survey off Sanriku are presented.

MATERIALS AND METHODS
While the sampling survey of common minke whale was conducted in the coastal waters within the 30 nautical miles (max 50 nautical miles) from Ayukawa port in Miyagi prefecture, the prey species survey was conducted in wider area at depths between 20 m and 200 m from 37º 40' N to 38º 40' N off Sanriku, northeastern Japan, to elucidate the distribution and abundance of main prey species (Fig. 1). To avoid the conflict with set nets in the coastal waters, the waters 10 miles from the coastal lines were excluded in principle. The survey area was divided into 7 blocks (A, B, C, D, E, F, and G) at depths of 40m/100m and 37º 40' N/37º 54' N/38º 15' N. Blocks E, F, and G south of 37º 54' N are located off Fukushima

prefecture. A zigzag track line was set to cover each block. The waypoints of planned track lines in each block were shown in Table 1.

The prey species survey was conducted from April 9 to 27 in blocks A, B, C, D, E, F and G by Takuyo Maru (Miyagi prefecture, 120 GT). The distribution and abundance of the prey species were investigated with the quantitative echosounder (EK 500) steaming at about 9-10 knots along the track lines. The survey was conducted during the daytime from an hour after sunrise to an hour before sunset. Oceanographic observations were conducted with CTD-EPCS (Continuous Sea Surface Water Monitoring System). With EPCS, temperature, salinity and chlorophyll in the surface water were measured every minute. Preliminary sighting survey was made for marine mammals such as northern fur seals.

Acoustic data were acquired with Echoview Ver.3 (Sonar Data Co., Ltd.) with operating frequency at 38, 120 and 200 kHz. Calibrations were carried out at a depth around 30m in Ishinomaki Bay (April 9 2007) using the copper sphere technique described in EK 500 manual. Trawl sampling was conducted to identify the species and size compositions of targeting echo signs. The trawl net had a mouth opening of 7 m width/3.5 m height and a 3 mm liner cod end. The depth and the height of the mouth of the net were monitored with a net recorder. Towing speed of the trawl net was 2-4 knots. Catches of trawl were identified to the species level and weighed aboard the vessel. For the major species, a sample of 100 animals was taken, and lengths and weights were measured. Scaled and standard lengths were used to anchovy and adult/juvenile sand lance, respectively. Total length from the tip of the rostrum to the end of the telson was used for krill. Some frozen samples were taken for further analysis in the laboratory.

RESULTS

The planned track lines were almost covered in the acoustic survey (95 %). A summary of the midwater trawl operations, temperature by depth and catches was shown on Table 2. Targeting trawlings were made 10 times and CTD observations were made at the trawling points and 26 waypoints. The oceanographic conditions are described in Appendix 2 in the report.

Acoustic data were analyzed with Echoview Ver.3 at the laboratory and the results are as follows. The surface water temperature in the survey area was between 8.2 ºC and 14.7 ºC based on EPCS. The surface water temperature of survey area was slightly higher than last year (6.7 ºC - 13.9 ºC) (Yonezaki *et al*., 2007), and many schools of Japanese anchovy were occurred during the prey species survey (Table 2). Echo signs identified as adult sand lance (> 10 cm in standard length) occurred at depths between 20 m and 60 m in blocks B, C, E, and F. Especially, many echo signs identified as adult sand lance were found in blocks F off Fukushima prefecture. The echo signs on the echograms were in the shape of patches on the bottom or sticks rising from the bottom. Juvenile sand lance could be identified from the difference in average Sv values between 38 and 120 kHz. Many echo signs identified as juvenile sand lance occurred in the shallower area of Sendai Bay (Blocks B and E). Most of the echo signs were smaller patches, usually found in the mid-layer. Although the difference in average Sv values by frequency is similar to that of krill, juvenile sand lance could be identified based on the distribution patterns and the size of the echo signs. Krill was frequently found at depths deeper than 70 m. In most cases the echo signs were large patches and in the shape of belts in the mid/bottom layers or sticks rising from the bottom.

We have constructed a Bayesian assessment model on sand lance in Sendai Bay (Okamura et al., 2007). This result will contribute to the development of the model of which the accuracy is higher.

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Table 1. Waypoints of planned lines.

Block A

WP	Latitude				Longitude				Course	Distance
A1	38	-	40.1	N	141	-	46.7	E	256	8.5
A2	38	-	38.0	N	141	-	36.1	E	104	12.0
A3	38	-	35.0	N	141	-	50.9	E	256	12.6
A4	38	-	32.0	N	141	-	35.3	E	104	12.2
A5	38	-	29.0	N	141	-	50.4	E	255	11.2
A6	38	-	26.0	N	141	-	36.6	E	105	11.4
A7	38	-	23.0	N	141	-	50.6	E	255	11.8
A8	38	-	20.0	N	141	-	36.0	E	105	11.4
A9	38	-	17.0	N	141	-	50.0	E	255	7.5
A10	38	-	15.0	N	141	-	40.8	E	-	-
									TOTAL	98.6

Block B

WP	Latitude				Longitude				Course	Distance
B1	38	-	21.0	N	141	-	16.2	E	107	6.8
B2	38	-	19.0	N	141	-	24.5	E	261	12.2
B3	38	-	17.0	N	141	-	09.2	E	104	8.1
B4	38	-	15.0	N	141	-	19.2	E	262	14.0
B5	38	-	13.0	N	141	-	01.6	E	100	11.2
B6	38	-	11.0	N	141	-	15.6	E	261	13.5
B7	38	-	09.0	N	140	-	58.7	E	98	13.9
B8	38	-	07.0	N	141	-	16.2	E	262	14.9
B9	38	-	05.0	N	140	-	57.5	E	98	13.6
B10	38	-	03.0	N	141	-	14.6	E	262	14.2
B11	38	-	01.0	N	140	-	56.8	E	98	13.6
B12	37	-	59.0	N	141	-	13.8	E	261	12.2
B13	37	-	57.0	N	140	-	58.6	E	101	10.9
B14	37	-	55.0	N	141	-	12.2	E	258	4.9
B15	37	-	54.0	N	141	-	06.1	E	-	-
									TOTAL	163.9

Block C

WP	Latitude				Longitude				Course	Distance
C1	38	-	17.0	N	141	-	24.0	E	247	3.8
C2	38	-	15.5	N	141	-	19.5	E	101	8.1
C3	38	-	14.0	N	141	-	29.6	E	261	9.1
C4	38	-	12.5	N	141	-	18.2	E	98	10.4
C5	38	-	11.0	N	141	-	31.3	E	263	11.8
C6	38	-	09.5	N	141	-	16.4	E	99	9.5
C7	38	-	08.0	N	141	-	28.3	E	261	9.7
C8	38	-	06.5	N	141	-	16.1	E	100	8.8
C9	38	-	05.0	N	141	-	27.1	E	261	10.0
C10	38	-	03.5	N	141	-	14.5	E	99	9.3
C11	38	-	02.0	N	141	-	26.1	E	261	9.4
C12	38	-	00.5	N	141	-	14.3	E	100	8.7
C13	37	-	59.0	N	141	-	25.2	E	261	9.3
C14	37	-	57.5	N	141	-	13.6	E	100	8.8
C15	37	-	56.0	N	141	-	24.6	E	261	9.9
C16	37	-	54.5	N	141	-	12.2	E	99	3.3
C17	37	-	54.0	N	141	-	16.3	E	-	-
									TOTAL	140.0

Block D

WP	Latitude				Longitude				Course	Distance
D1	38	-	15.0	N	141	-	40.6	E	106	7.2
D2	38	-	13.0	N	141	-	49.4	E	259	15.2
D3	38	-	10.0	N	141	-	30.4	E	102	14.9
D4	38	-	07.0	N	141	-	48.9	E	260	17.7
D5	38	-	04.0	N	141	-	26.8	E	100	17.0
D6	38	-	01.0	N	141	-	48.0	E	261	18.5
D7	37	-	58.0	N	141	-	24.8	E	103	13.4
D8	37	-	55.0	N	141	-	41.1	E	258	4.8
D9	37	-	53.9	N	141	-	35.0	E	-	-
									TOTAL	108.8

Block E

WP	Latitude				Longitude				Course	Distance
E1	37	-	54.0	N	141	-	08.3	E	261	6.6
E2	37	-	53.0	N	141	-	00.0	E	98	10.2
E3	37	-	51.5	N	141	-	12.8	E	260	8.4
E4	37	-	50.0	N	141	-	02.3	E	101	7.8
E5	37	-	48.5	N	141	-	12.0	E	259	8.1
E6	37	-	47.0	N	141	-	02.0	E	106	5.4
E7	37	-	45.5	N	141	-	08.6	E	252	4.9
E8	37	-	44.0	N	141	-	02.7	E	104	6.0
E9	37	-	42.5	N	141	-	10.1	E	256	6.3
E10	37	-	41.0	N	141	-	02.4	E	105	3.9
E11	37	-	40.0	N	141	-	07.1	E	-	-
									TOTAL	67.7

Block F

WP	Latitude				Longitude				Course	Distance
F1	37	-	54.0	N	141	-	12.3	E	103	9.1
F2	37	-	52.0	N	141	-	23.6	E	256	8.5
F3	37	-	50.0	N	141	-	13.1	E	104	8.2
F4	37	-	48.0	N	141	-	23.1	E	259	10.2
F5	37	-	46.0	N	141	-	10.4	E	103	9.1
F6	37	-	44.0	N	141	-	21.6	E	257	8.9
F7	37	-	42.0	N	141	-	10.6	E	103	8.7
F8	37	-	40.0	N	141	-	21.3	E	-	-
									TOTAL	62.8

Block G

WP	Latitude				Longitude				Course	Distance
G1	37	-	54.0	N	141	-	24.4	E	99	12.4
G2	37	-	52.0	N	141	-	39.9	E	261	13.4
G3	37	-	50.0	N	141	-	23.1	E	99	12.1
G4	37	-	48.0	N	141	-	38.2	E	261	12.4
G5	37	-	46.0	N	141	-	22.7	E	100	11.7
G6	37	-	44.0	N	141	-	37.3	E	261	12.8
G7	37	-	42.0	N	141	-	21.4	E	100	11.7
G8	37	-	40.0	N	141	-	35.9	E	-	-
									TOTAL	86.5

Table 2. A summary of the trawl sampling operations, temperature by depth and catches.

Station		St-1	St-2	St-3	St-4	St-5	St-6	St-7	St-8
Date		4/11	4/11	4/12	4/12	4/18	4/23	4/23	4/25
Time		7:29	9:41	5:56	10:31	14:42	7:51	10:40	5:57
Latitude		38-07	38-05	37-56	37-56	38-04	38-17	37-58	37-54
Longitude		141-16	140-58	140-59	141-23	141-28	141-14	141-01	141-12
Block		B	B	B	C	D	B	B	F
Surf. Temp.		8.90	9.70	9.62	9.29	9.28	10.0	10.67	10.02
Depth temp.	10 m	8.86	9.06	9.66	8.98	8.93	9.88		9.81
	20 m	8.84			8.74	8.89	8.78		9.12
	30 m	8.66			8.53	8.88			8.55
	40 m	8.35			8.38	8.87			8.52
	50 m				8.02	8.82			
	75 m				6.81	8.10			
	100 m					8.11			
	125 m								
Depth (m)		41	19	18	80	102	26	22	40
Net depth (m)		22-27	12-19	9-18	75-80	90-100	15-25	10-20	20-30
Major species caught, (Average length (mm))		Jelly fish	Juvenile sand lance (54)	Juvenile sand lance (58)	Adult sand lance	Krill (17)	Japanese anchovy (110), Krill (18), Juvenile sand lance (42)	Japanese anchovy (90), Juvenile sand lance (64)	Japanese anchovy (120), Adult sand lance (120)
Catches (kg)		< 0.1	3.7	4.6	0.8	1.6	20.1	7.7	0.05

Station		St-9	St-10
Date		4/25	4/26
Time		7:46	13:46
Latitude		37-49	38-28
Longitude		141-18	141-46
Block		F	A
Surf. Temp.		9.73	9.12
Depth temp.	10 m	9.61	9.14
	20 m	9.17	8.73
	30 m	8.79	8.67
	40 m	8.70	8.59
	50 m	8.46	8.30
	75 m		7.98
	100 m		7.35
	125 m		7.29
	150 m		6.28
Depth (m)		71	162
Net depth (m)		45-55	150-160
Major species caught, (Average length (mm))		Japanese anchovy (120), Adult sand lance	Krill (18)
Catches (kg)		6.5	3.1

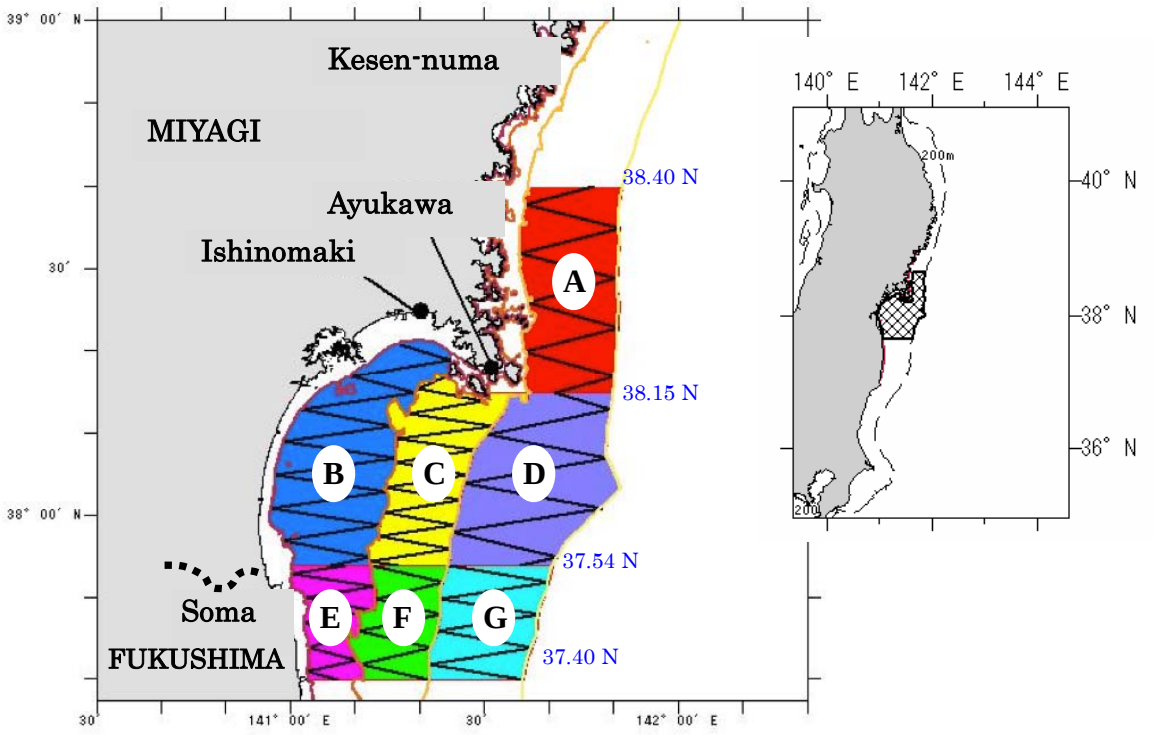

Fig. 1. Survey area and blocks of prey species survey in 2007 off Sanriku.

Appendix 2

Oceanographic conditions in the coastal survey of JARPN II off Sanriku, northeastern Japan, in April 2007

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ABSTRACT
A prey species survey was conducted in the coastal region off Sanriku, northeastern Japan, concurrently with the coastal sampling survey for common minke whales during spring 2007 as a part of JARPN II study. Oceanographic observations were conducted with CTD from 10 to 27 April 2007 by *Takuyo-Maru*. According to the CTD data at 33 stations, water masses in the survey area have characteristics of the Cold water (5ºC < temperature < 10ºC at 100 m depth).

Introduction

The oceanographic condition at the Tohoku area, northeastern Japan, is one of the most complicated areas in the world. In this area, there are a lot of fronts and water masses. The Kuroshio flows northward along the coast of southern Japan to the southern part of the Tohoku area with warm high-salinity water. The Oyashio flows southwestward along the Kuril Islands to the northern part of the Tohoku area with cold low-salinity water. The Kuroshio and the Oyashio flows eastward from the Tohoku area, and the area between the Kuroshio and Oyashio was usually called the Kuroshio-Oyashio Inter-frontal Zone or perturbed area. The Tsugaru warm water enters into the Inter-frontal Zone through Tsugaru Strait and flows southward along the coast of Sanriku. And also the warm-core ring is cut off from the Kuroshio extension into the Inter-frontal Zone. Each water mass is mixed with others, and make a new water mass. Oceanographic condition of the coastal area off Sanriku is the most variable in the Tohoku area, because the Kuroshio, the warm-core ring, the Oyashio, the Tsugaru warm water and other water arrive here by turns.

A prey species survey was conducted on board *Takuyo-Maru* (Miyagi prefecture, 120 GT) in the coastal region off Sanriku, northeastern Japan, concurrently with the coastal sampling survey for common minke whales during spring 2007 as a part of JARPN II study. Oceanographic observations were conducted with Conductivity Temperature Depth profiler (CTD) by *Takuyo-Maru*. In this paper, we analyzed the CTD data to make clear the oceanic environment in the survey area.

Data and Methods

Hydrographic observations with CTD (SBE 19) were carried out at 33 stations from 10 to 27 April 2007 in the coastal area off Sanriku, northeast of Japan (Fig. 1). Salinity correction for CTD data was not done using water sampling data.

Oceanic fronts and water masses are usually detected by subsurface temperature map (see Table 1), because they are obscure in sea surface temperature distributions from summer to fall seasons and the Oyashio water spreads into the subsurface layer. So, the oceanographic conditions in April 2007

(Fig. 2) are detected by 100m and 200m temperature maps using the monthly mean subsurface temperature in seas around Japan from NEAR-GOOS (the North-East Asian Regional-Global Ocean Observing System) database.

Oceanographic conditions in the survey area

Figure 3 shows the Temperature-Salinity diagrams using CTD data. Almost all water mass in the survey area have characteristics of the Cold water. A few stations show low-salinity water (less than 33.5 psu) in the shallow layer, which is mixed with the coastal water.

Figure 2 shows the schematic hydrographic map in April 2007. The northern limit of the Warm water spreading from the Kuroshio Extension moves northward from March to November. The position of the Warm water in April 2007 was at 39ºN on 146ºE line, which was a slightly northward position from monthly mean location in April (38º40'N). Tsugaru warm water was obscure because it restricted near the coastal area (called as coastal mode) in April. The southern limit of the first Oyashio Intrusion located around 39º30'N, 143ºE, which was a little northward position from monthly mean location in April (38º30'N). All stations in the survey area were distributed in the Cold water defined by 100 m temperature which is over 5ºC and less than 10ºC.

Figure 4 shows temperature and salinity maps at the depth of 90 m, observed by *Takuyo-Maru*. Water of 8ºC to 9ºC and 33.7 to 33.8 psu were dominant at the depth of 90 m in Fig. 4. It means that the Cold water occupied in these survey area.

Figure 5 shows vertical sections of temperature and salinity. Cold low salinity water (8 to 10ºC and less than 34 psu) was dominant at the shallow layer near the coast in Fig. 5. Temperature at the depth of 100 m is around 8 ºC at the most offshore station in each section.

All of these figures show that all stations are distributed in the cold area, south of the Oyashio. The surface layer on the shelf off Sanriku was occupied by coastal low-salinity water.

Acknowledgment

A special thank is given to Crews of *Takuyo-Maru* for their dedication in collecting data.

References

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Table 1. Extraction method from temperature map to determine the position of each water mass according to Kawai (1969) and Murakami (1994).

Target characteristics	Extraction method
Kuroshio Extension Axis	14 ºC isotherm at 200 m
Warm-core ring	Temperature front at 200 m
Oyashio front	5ºC isotherm at 100 m
Oyashio water	Area with T < 5ºC at 100 m
Cold water	Area with 5ºC < T < 10ºC at 100 m
Warm water	Area with T > 10ºC at 100 m and T < 14ºC at 200 m

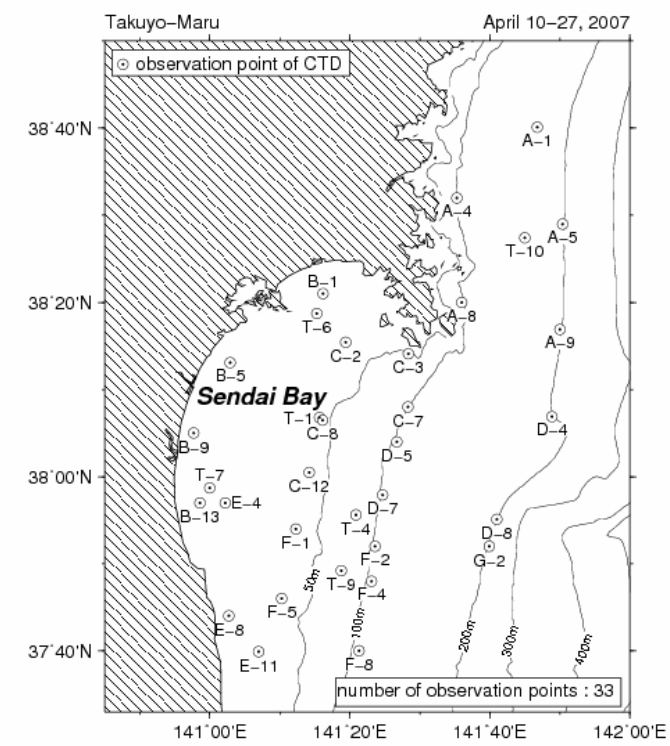

Fig. 1. Station map observed by *Takuyo-Maru* in April 10 to 27, 2007.

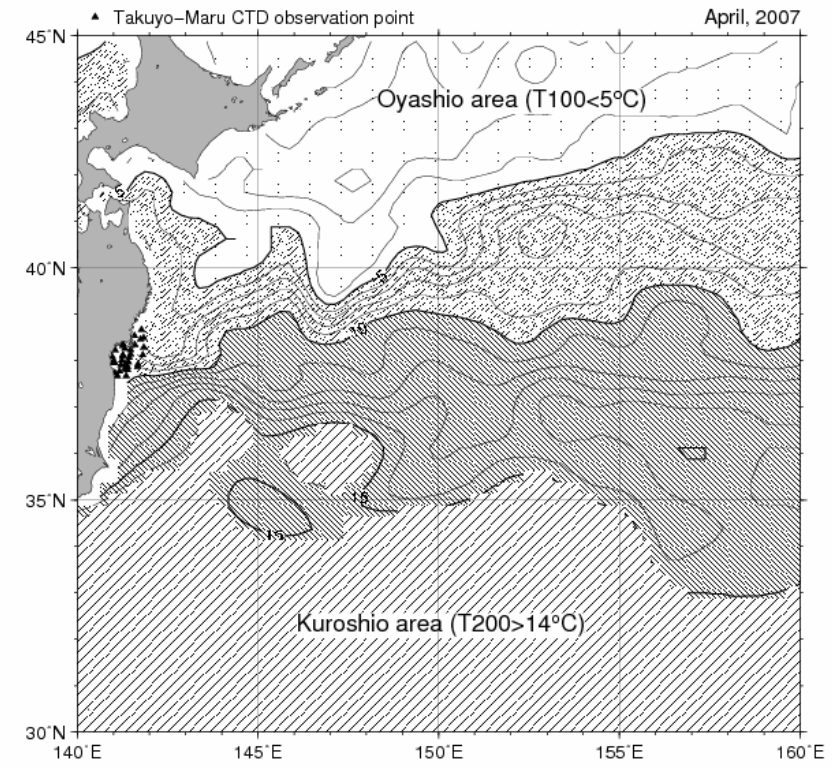

Fig. 2. Schematic hydrographic map in Tohoku area, northwestern Pacific, in April 2007 with

station map observed by *Takuyo-Maru* (▲) .

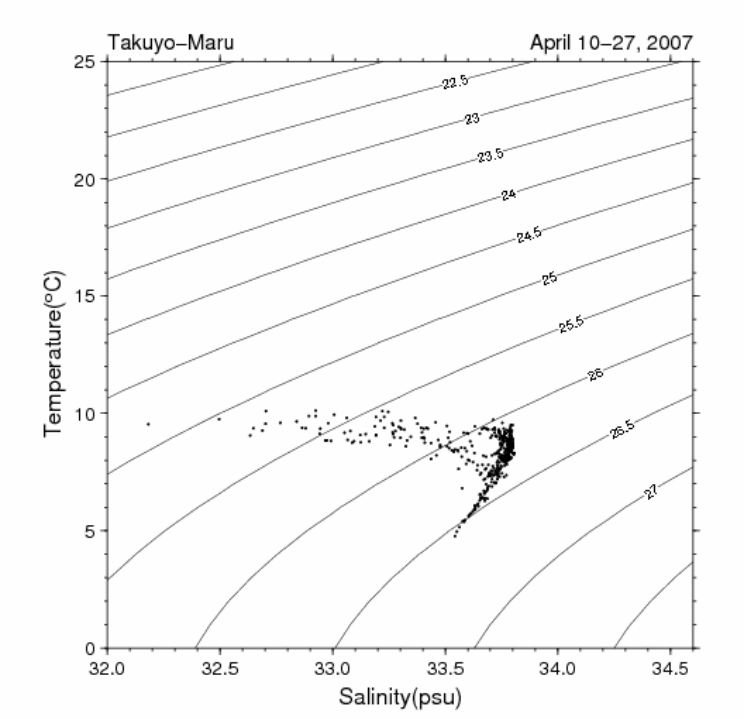

Fig. 3. Temperature-Salinity diagrams using CTD station data observe by *Takuyo-Maru* in April 10 to 27, 2007. Each thin line in this figure denotes a density line of sigma-t.

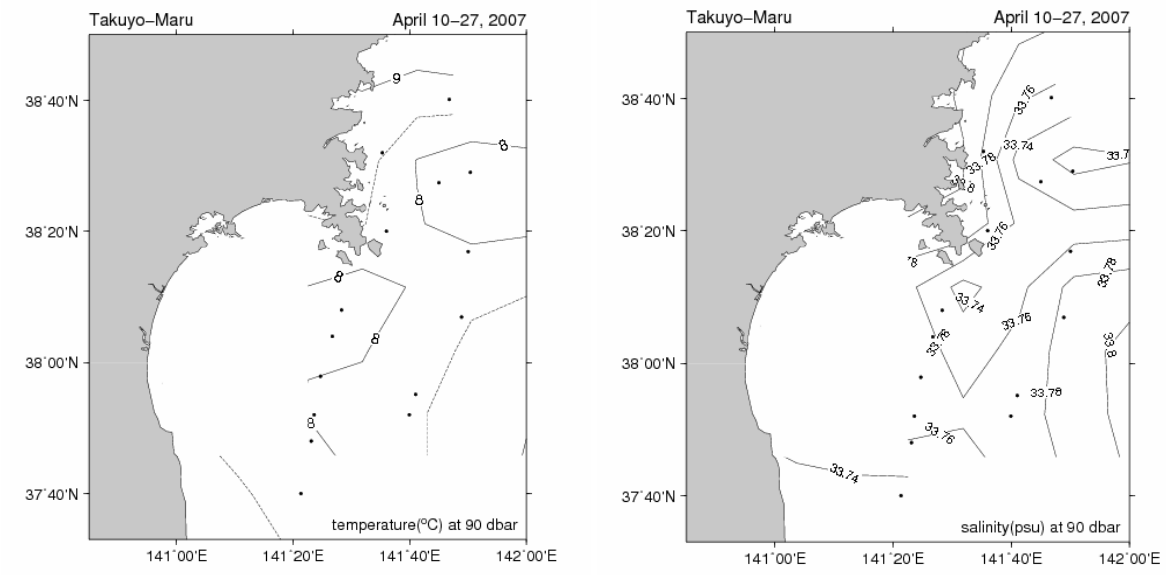

Fig.4. Temperature (left panel) and salinity (right panel) maps at 90 m depth, observed by *Takuyo-Maru* in 10 to 27 April 2007.

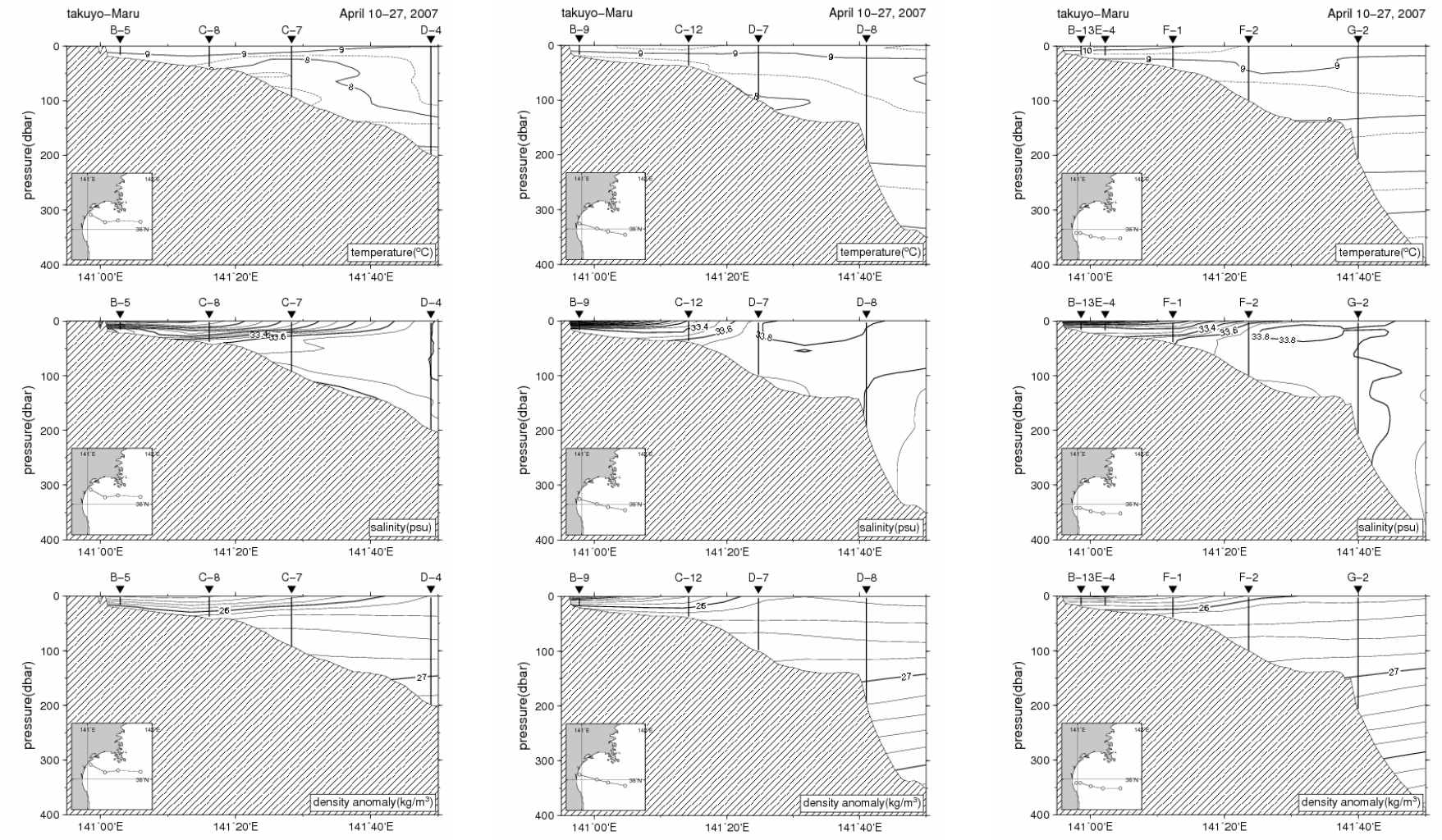

Fig.5. Temperature (top), salinity (middle) and density anomaly (bottom) sections along selected stations, observed by *Takuyo-Maru* in 11 to 27 April 2007.