Report of the coastal survey on common minke whales off Sanriku coast, northeast Japan: the Japanese Whale Research Program under Special Permit in the western North Pacific - Phase II (JARPN II) in 2003 (Part II) - Coastal component.

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ABSTRACT

The second survey of the JARPN II coastal component was conducted from 8 April to 2 May 2003, off the Sanriku coast, northeast Japan (middle part of the sub-area 7), using four small-type whaling catcher boats, one echo sounder-trawl survey vessel, and one dedicated sighting survey vessel. Sampling of common minke whales was conducted in the coastal waters within 30 nautical miles from Ayukawa port in the Sanriku, and all animals collected were landed on the JARPN II research station established in the port for biological examination. During the survey, a total of 3,833.6 n. miles (342.9 hours) was surveyed for whale sampling, and 184 schools (188 individuals) of the common minke whale were sighted and 50 animals were caught. Average body length of the animals was 6.28m (SD=0.89, *n*=21) for males and 6.30m (SD=1.12, *n*=29) for females. Dominant prey species found from the first stomach of the animals were Japanese sand lance *Ammodytes personatus* and Krill *Euphausia pacifica*. The present survey was conducted to cover the temporal and spatial gap, in which the *Nisshin-Maru* and the large research vessels can not be operated. No serious practical problem occurred during the present survey. Thus, the 2003 coastal survey off the Sanriku was conducted successfully.

KEYWORDS: COMMON MINKE WHALE; NORTH PACIFIC; FOOD/PREY; ECOSYSTEM; SCIENTIFIC PERMITS

INTRODUCTION

After the two-year feasibility study in 2000-2001, the full-scale survey of the Japanese Whale Research Program under Special Permit in the western North Pacific-Phase II (JARPN II) was started in 2002. The main purpose of the program is to evaluate competition between whales and fisheries, and to clarify the role of the cetaceans in the marine ecosystem of the western North Pacific (Government of Japan, 2002a). The target species in the full-scale JARPN II are the common minke whale *Baraenoptera acutorostrata*, the Bryde's whale *B. edeni*, the sei whale *B. borealis* and the sperm whale *Physeter macrocephalus*.

The JARPN (1994-1999) and the JARPN II feasibility study (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 is also very important fishing ground. Thus, it is thought that competition between the whales and fisheries is severe in the coastal waters. However, the *Nisshin-Maru* and large research vessels can not be operated in the near shore areas, because of their movement restrictions. Furthermore, the vessels can not work in the coastal waters 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 introduced. This coastal survey was planned as the feasibility study in the first two years (2002 and 2003) in order to check the logistic feasibility and consisted of three research components as follows; 1) coastal whale sampling survey by small-type whaling vessels, 2) coastal prey species survey by one echo sounder-trawl survey vessel, and 3) dedicated sighting survey by one research vessel. The coastal survey was authorized by the Government of Japan in compliance with Article VIII of the International Convention for the Regulation of Whaling. The National Research Institute of Far Seas Fisheries (NRIFSF), Fisheries Research Agency, planned and conducted the survey entrusted by the Institute of Cetacean Research (ICR).

The first feasibility survey was conducted from 10 September to 12 October 2002 in coastal waters off Kushiro, northeast Japan and finished successfully (Kishiro *et al*. 2003). In the present paper, we show results of the second survey carried out in coastal waters off the Sanriku, Japan, from 8 April to 2 May 2003.

MATERIALS AND METHODS

Research area

In coastal waters off the Sanriku district (northeast part of the Pacific coast of the Japanese main island, Honshu), many common minke whales were taken, especially in spring, by the past land-based coastal whaling (Miyashita and Hatanaka, 1997). The coastal waters is also very important fishing grounds. Thus, the waters is thought to be suitable for the study area to evaluate competition between whales and coastal fisheries. For the whale sampling survey, we established the research area within the 30 nautical miles from the Ayukawa port in the Sanriku (Fig. 1). The distance, 30 n. miles, was placed after discussion, to keep freshness of whale stomach contents. The survey area is included in the middle part of the sub-area 7 determined by the IWC.

Research vessels and station

Whale sampling survey

Four small-type whaling catcher boats, *Taisho Maru* No. 28 (hereinafter referred as T28; 47.3GT), *Koei Maru* No. 75 (75K; 46.0GT), *Katsu Maru* No.7 (7K; 32.0GT), and *Sumitomo Maru* No.31 (31S; 32.0GT) were used as sampling vessels. The sampling survey was conducted from 10 April to

2 May, 2003. All the animals collected were landed on the JARPN II research station established in the Ayukawa port for biological examination and by-products.

Prey species survey

The *Kaiyo Maru* No.7 (KY7; 499.0GT), the echo sounder-trawling survey vessel, conducted the prey species survey in wider research area off northeast coast of Honshu, from 8 to 28 April. This area included the coastal waters off the Sanriku, where the sampling survey was carried out. Detail of the prey species survey is shown in Appendix 1. The *Kaiyo maru No. 7* also conducted the hydrographic observations using the conductivity-temperature-depth profiler (CTD; SBE 19plus SEACAT Profiler) from 10 to 24 April in the Kuroshio-Oyashio Inter-frontal Zone. Oceanographic conditions revealed from the observations are shown in Appendix 2.

Dedicated sighting survey

The *Shonan Maru* (SM1; 712.0GT) was engaged as a dedicated sighting survey vessel. The sighting survey was also conducted from 8 to 28 April, following zigzag track lines predetermined in the identical research area, where the prey species survey was carried out. Detail of the survey is shown in Appendix 3.

Sighting and sampling methods

Sighting and sampling methods were same in the first survey conducted in Kushiro 2002 (Kishiro *et al*. 2003). The research head office was placed in the research station and controlled the sampling vessels during the survey. The office determined the searching area and routes of sampling vessels everyday, from weather conditions, whale distribution, and information on fishing grounds.

In each sampling vessel, a researcher was onboard and recorded sighting and sampling information, e.g., coordinates and time of common minke whales sighting and sampling made, weather conditions, and vessel movements. Sighting information was also recorded for other baleen whales and sperm whales. Searching effort was conducted from the top barrel and upper bridge by all the crews and the researcher. All common minke whales sighted were targeted for sampling, except for the cow-calf pair. When a school consisted of plural animals, sampling target was selected randomly from the school. Sampling was carried out using 50 mm whaling cannon. Once the vessel caught a whale, she returned to the Ayukawa port as soon as possible, to land the animal on the research station. At the port, animals taken were lift up from the vessel by the crane, using a wire net and then transported to the station by a 11-tons freight trailer. At that time, animal 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, with the number of data and samples

obtained. 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 the four sampling vessels (28T, 75K, 7K, and 31S) during the survey are shown in Fig.2a. The searching areas covered widely coastal waters within 30 nautical mails form the Ayukawa port, but most of them concentrated in the middle part of Sendai Bay. Searching distance and time made by four sampling vessels are listed in Table 1. Here, searching distance and time are defined as the distance and time recorded under the searching effort from the top barrel of the vessels. Total searching distance and time made by the four vessels were 3,833.6 n. miles and 342.9 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. 2b. During the survey, a total of 184 schools (188 animals) of common minke whales were sighted: 157 schools (161 animals) of primary sightings and 27 schools (27 animals) of secondary sightings (Table 2). These figures probably include some duplicated sightings made by plural vessels, because sampling vessels searched almost same areas. In the last survey in Kushiro 2002, large cetaceans, e.g., fin whales and humpback whales, were sighted (Kishiro et al. 2003), but no sightings of other large cetaceans were obtained in the present survey. Table 3 shows temporal change in density index (SPUE: number of primary school sightings per one hour searching, and DI: number of primary school sightings per 100 n. miles searching) of common minke whales recorded by the sampling vessels. Both SPUE and DI increased from the first to second period of the survey, and then decreased in the third period. During the survey, primary sightings of 0.47 schools were recorded per one hour searching, and primary sightings of 4.20 schools were obtained per 100 n. miles searching. These figures are nearly the same recorded in the last survey conducted in Kushiro 2002 (Kishiro *et al*. 2003).

Sampling of common minke whales

A total of 50 common minke whales were taken for biological research. In the sampling process, there were no harpooned-missed animals (i.e., no struck-lost animals). Sampling positions of individuals are shown in Fig. 2c. Animals were taken evenly from whales sighted.

Prey species survey and dedicated sighting survey

The prey species survey was conducted using the echo sounder-trawling survey vessel (KY7). The distribution and abundance of the prey species were investigated with the mid-water trawl, IKMT(Isaacs-Kidd Midwater Trawl), Bongo net, and quantitative echosounder (EK60). The Japanese anchovy, sand lance, and krill were found. The dedicated sighting survey was carried out

using the sighting survey vessel (SM1). Four schools of common minke whales were detected. Sightings of the fin whale, the humpback whale, the right whale, and the sperm whale were also obtained. Results of these surveys are noted in Appendix 1 (the prey species survey), Appendix 2 (the oceanographic observations), and Appendix 3 (the dedicated sighting survey).

Sex ratio, body length and weight of sampled whales

The 50 animals taken consisted of 21 males and 29 females (sex ratio of males to all animals was 0.42). Average body length of animals was 6.28m (max=7.83, min=4.70, SD=0.89) for males and 6.30m (max=8.02, min=4.28, SD=1.12) for females (Table 5). Average body weight was 2.92 tons (max=5.06, min=1.32, SD=1.08) for males and 3.12 tons (max=6.15, min=0.87, SD=1.46) for females (Table 6). In males, the average body length and the average body weight were largest at the second period of the survey. In females, the averages were the lowest at the third period.

Composition of sex and sexual maturity of minke whales collected is listed in Table 7. In males, eight of 21 animals were sexually mature (38.1%) and nine of 29 females attained sexual maturity (42.0%). All the mature females were pregnant with 3.65-27.2cm foetuses (Table 8) and lactating or resting females were not observed.

Prey species of common minke whale found in the stomach contents

Following the same methods used in the JARPN II feasibility surveys (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, a small sample of the first stomach contents was collected and frozen for the laboratory observation. Major prey species found in the first stomach contents were Japanese sand lance *Ammodytes personatus* (% in weight = 49.9%) and krill *Euphausia pacifica* (35.1%; Table 9). The Japanese anchovy *Engraulis japonicus* collected was only 2.0% in the total weight. Unidentified fishes (13.0%) were also thought to be sand lances. In the first period, krill was dominant species found from the first stomach. However, the occurrence frequency of krill reduced with time and, in the third period, sand lances were found most frequently. The range of weights of the first stomach contents was from 1.3kg to 102.6kg. The maximum weight (102.6kg), which was sand lances, was found from a male with body weight of 5040kg. The weight of stomach contents was 2.0% of his 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 77.7 tons.

DISCUSSION

The present survey was the second survey of the JARPNII coastal component conducted in coastal

waters of Japan, using the small-type whaling catcher boats as the sampling research vessel. In the research area, there were many fishing boats operating coastal fisheries such as the stick-held dip netting for sand lances. Many set nets were also placed. The sampling vessels, however, could go into the inshore areas and take samples beside the fishing boats and nets without any problems and accidents. The prey species survey and the dedicated sighting survey were also conducted, following the predetermined schedules and survey lines.

The dominant prey species of common minke whales found in the present survey was very different from species obtained by the JARPN II offshore surveys (Tamura *et al*. 2004) and the coastal survey off Kushiro, 2002 (Kishiro *et a*l. 2003). The sand lance, which was dominant prey species in whale stomachs taken in the present survey, was not collected by the other JARPN II surveys, in which the walleye Pollock, the Japanese anchovy, the Pacific saury, and the Japanese common squid were dominant. This result indicates that many sand lances are distributed in coastal waters off the Sanriku of Japan. Indeed, the prey species survey found many sand lances in the waters (see, appendix 1) and the sand lance is one of the most important target species of coastal fisheries in this area. The present survey revealed that common minke whales feed many sand lances and krills in the coastal waters on their northward way to feeding grounds. Our results imply the existence of competition between minke whales and coastal fisheries in waters off the Sanriku.

The present survey was finished with no serious problem and accident. Unfortunately, a small number of common minke whale sightings was recorded at the dedicated sighting survey, probably from low coverage of survey lines in high density area, i.e., in the middle part of Sendai Bay. From the viewpoint of the logistic feasibility, however, we concluded that the 2003 coastal survey off the Sanriku coast was also conducted successfully, as the last year survey off Kushiro.

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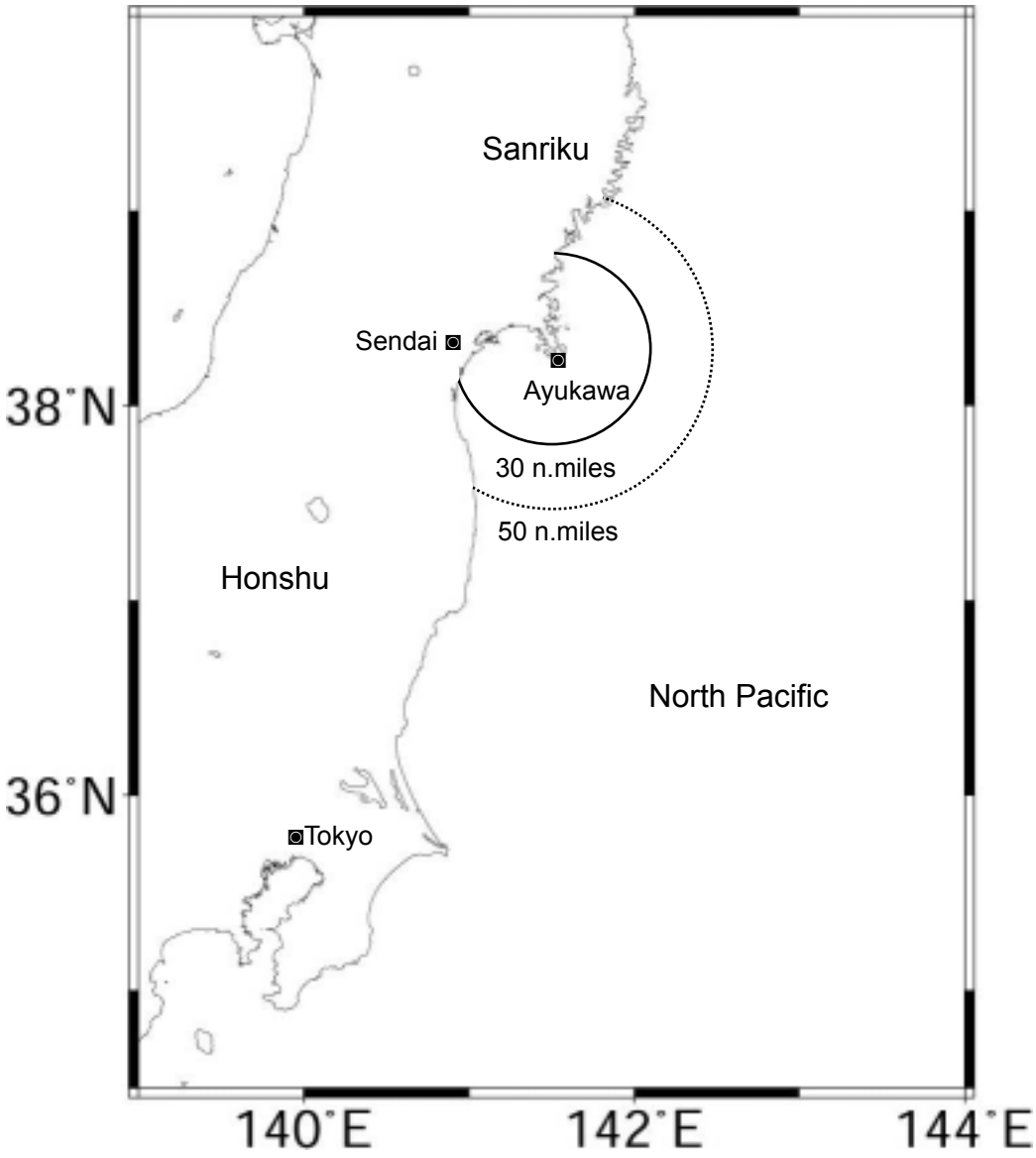

Fig. 1. Research area of the 2003 coastal surveys in the JARPN II.

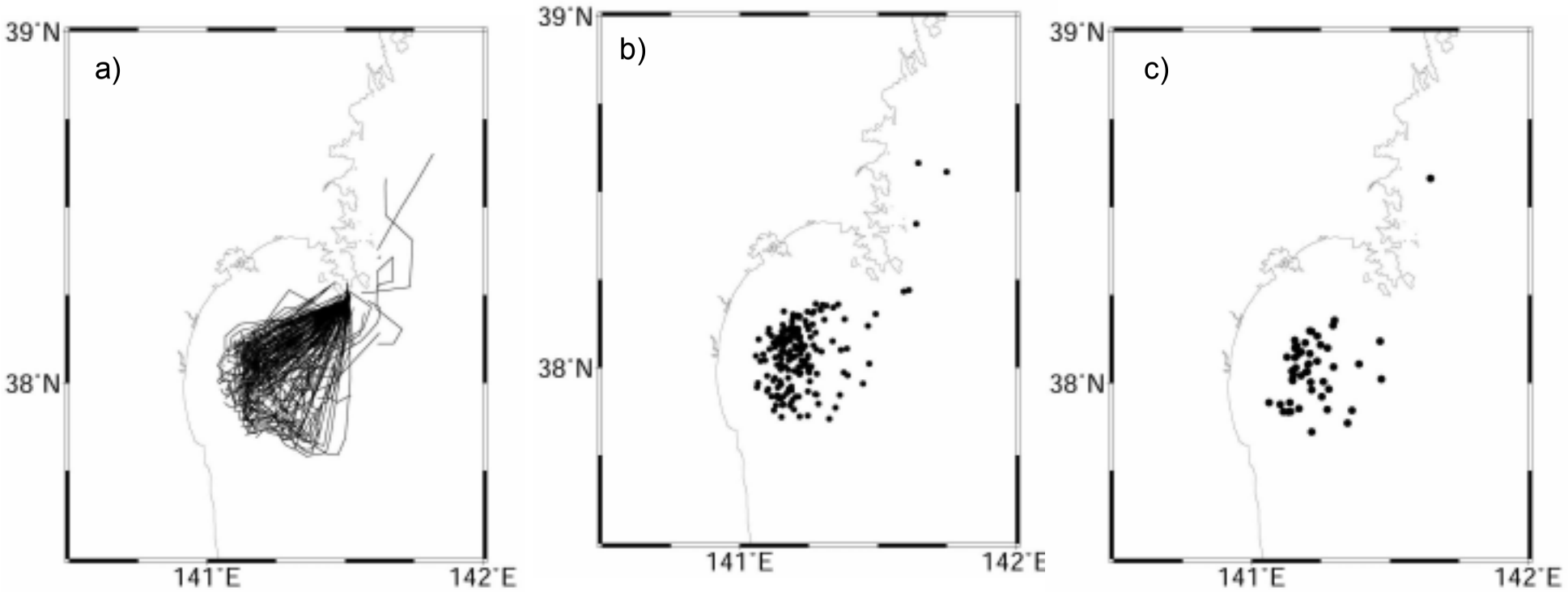

Fig. 2. Cruise tracks (a), and sighting positions (b) and catch positions (c) of common minke whales made by sampling vessels during the 2003 coastal survey.

Table 1. Searching days, hours, distances made by four sampling vessels in the 2003 coastal whale survey off Sanriku, in the JARPN II.

Period		Sampling vessels*[1]				Total
		28T	75K	7K	31S	
First period	Days	6	6	6	6	24
(10 Apr.-16 Apr.)	Hours	42.1	34.6	44.7	40.1	161.5
	Distances (n. miles)	465.2	385.4	497.9	433.8	1782.3
Second period	Days	4	4	4	4	16
(17 Apr.-23 Apr.)	Hours	19.3	19.6	16.4	21.0	76.2
	Distances (n. miles)	214.4	224.4	190.9	234.2	863.9
Third period	Days	6	5	5	6	22
(24 Apr.-2 May)	Hours	27.8	22.7	23.8	31.0	105.2
	Distances (n. miles)	311.8	262.5	266.2	346.9	1187.4
Total	Days	16	15	15	16	62
	Hours	89.1	76.8	84.9	92.1	342.9
	Distances (n. miles)	991.4	872.3	955.0	1014.9	3833.6

*[1]: 28T; *Taisho Maru* No. 28; 75K: *Koei maru* No. 75; 7K: *Katsu Maru* No. 7; 31S: *Sumitomo maru* No. 31.

Table 2. Cetacean species and number of sightings made by the four sampling vesels in the 2003 coastal whale survey off Sanriku, in the JARPN II.

Period	Species	Primary*		Secondary*		Total*	
		Sch.	Ind.	Sch.	Ind.	Sch.	Ind.
First period	Common minke whale	64	66	13	13	77	79
(10 Apr.-16 Apr.)	Like minke whale	9	9	1	1	10	10
	Unidentified cetacean	-	-	1	1	1	1
Second Period	Common minke whale	42	44	5	5	47	49
(17 Apr.-23 Apr.)	Like minke whale	6	6	-	-	6	6
Third period	Common minke whale	51	51	9	9	60	60
(24 Apr.-2 May)	Like mnke whale	7	7	-	-	7	7
Total	Common minke whale	157	161	27	27	184	188
	Like minke whale	22	22	1	1	23	23
	Unidentified cetacean	-	-	1	1	1	1

*: These figures probably include some duplicated sightings made by plural vessels.

Table 3. Density index of common minke whales in the 2003 coastal whale survey off Sanriku, in the JARPN II.

Period	Primary sightings		Searching	Distance	SPUE*[1]	DI*[2]
	Sch.	Ind.	hours	(n. mile)		
10 Apr.-16 Apr.	64	66	161.5	1782.3	0.40	3.59
17 Apr. -23 Apr.	42	44	76.2	863.9	0.55	4.86
24 Apr. -2 May	55	56	105.2	1187.4	0.52	4.63
Total	161	166	342.9	3833.6	0.47	4.20

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

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

Table 4. Sumarry of biological data and samples collected during the 2003 coastal whale survey off Sanriku, in the JARPN II.

Samples and data	Number of whales		
	Male	Female	Total
Body length and sex	21	29	50
External body proportion	21	29	50
Photographic record and external character	21	29	50
Diatom film record and sampling	21	29	50
Body scar record	21	29	50
Measurements of blubber thickness (eleven points)	21	29	50
Body weight	21	29	50
Body weight by parts	1	-	1
Skin tissues for DNA study	21	29	50
Muscle, liver, and heart tissues for isozyme analysis	21	29	50
Muscle, liver, kidney, and blubber tissues for chemical analysis	21	29	50
Muscle, liver, blubber, vertebrae, and stomach contents for lipid analysis	1	-	1
Mammary grand; lactation status, measurement and histological sample	-	29	29
Uterine horn; measurements and endometrium sample	-	28	28
Collection of Ovary	-	28	28
Photographic record of foetus			8
Foetal length and weight			8
External measurement of foetus			8
Collection of foetus			9
Testis and epididymis; weight and histological sample	21	-	21
Stomach contents, convenient record	21	29	50
Volume and weight of stomach content in each compartment	21	28	49
Marine debris in stomach	21	29	50
Stomach contents for feeding study	21	28	49
Record of external parasites	21	29	50
Sampling of the intestine contents	3	7	10
Earplug age determination	21	29	50
Tympanic bulla for age determination	21	29	50
Largest baleen plate for morphologic study and age determination	21	29	50
Baleen plate measurements (length and breadth)	21	28	49
Photographic record of baleen plate series	21	29	50
Length of each baleen series	21	29	50
Vertebral epiphyses sample	21	29	50
Number of vertebrae	21	29	50
Number of ribs	21	29	50
Skull measurement (length and breadth)	20	28	48

Table 5. Body length (m) of common minke whales collected by the 2003 coastal whale survey in the JARPN II.

Period	Male					Female				
	Mean	S.D.	Min.	Max.	*n*	Mean	S.D.	Min.	Max.	*n*
10 Apr. -16 Apr.	6.10	0.47	5.76	6.92	5	6.52	0.99	5.05	7.96	15
17 Apr. -23 Apr.	6.38	1.07	4.94	7.83	7	6.51	1.31	4.58	8.02	8
24 Apr. -2 May	6.30	0.99	4.70	7.35	9	5.50	0.98	4.28	6.87	6
Total	6.28	0.89	4.70	7.83	21	6.30	1.12	4.28	8.02	29

Table 6. Body weight (t) of common minke whales sampled by the 2003 coastal whale survey in the JARPN II.

Period	Male					Female				
	Mean	S.D.	Min.	Max.	*n*	Mean	S.D.	Min.	Max.	*n*
10 Apr. -16 Apr.	2.77	0.85	2.08	4.22	5	3.38	1.42	1.54	6.15	15
17 Apr. -23 Apr.	3.02	1.36	1.45	5.06	7	3.46	1.61	1.29	5.50	8
24 Apr. -2 May	2.92	1.07	1.32	4.15	9	2.01	0.86	0.87	3.31	6
Total	2.92	1.08	1.32	5.06	21	3.12	1.46	0.87	6.15	29

Table 7. Composition of sex and sexual maturity of common minke whales sampled by the 2003 coastal whale survey in the JARPN II.

Period	Male				Female						
	Imm.	Mat.	Total	Maturity (%)	Imm.*[1]	Mat.	Preg.	Total	Pregnancy (%)*[2]	Maturity (%)	Sex ratio (%Males)
10 Apr. -16 Apr.	4	1	5	20.0	10	5	5	15	100.0	33.3	25.0
17 Apr. -23 Apr.	4	3	7	42.9	4	4	4	8	100.0	50.0	46.7
24 Apr. -2 May	5	4	9	44.4	6	0	0	6	0.0	0.0	60.0
Total	13	8	21	38.1	20	9	9	29	100.0	31.0	42.0

*[1]: Include an individual estimated from body length (6.09m) due to lack of the ovary sample.

*[2]: Apparent pregnancy rate.

Table 8. Pregnant females and their foetus sampled by the 2003 coastal whale survey in the JARPN II.

Sample No.	Catch date	Pregnant Female		Foetus	
		Body length (m)	Body weight (t)	Body length (cm)	Body weight (g)
03NPCM001	11 April	7.84	4.31	3.65	-
03NPCM005	11 April	7.68	4.89	20.9	141.2
03NPCM010	14 April	7.96	6.15	10.5	23.8
03NPCM013	15 April	7.26	4.35	27.2	30.0
03NPCM020	16 April	7.65	5.46	7.9	14.1
03NPCM027	18 April	7.45	4.70	12.1	35.1
03NPCM031	19 April	7.66	4.85	11.8	71.7
03NPCM034	22 April	8.02	5.50	8.8	16.7
03NPCM035	22 April	7.14	4.24	14.0	46.4

Table 9. Stomach contents (% in weight) of common minke whales sampled by the 2003 coastal survey in the JARPN II (first stomach).

Period	Sample Size	Prey species (%)			
		Sand lance	Krill	Japanese anchovy	Unidentified fish
10 Apr. -16 Apr.	20	20.3	74.8	0.05	0.0
17 Apr. -23 Apr.	15	56.0	8.3	0.0	35.7
24 Apr. -2 May	14*	92.2	7.7	0.001	0.0
Total	49*	49.9	35.1	2.0	13.0

* An animal with broken stomach by harpoon is unlisted.

Appendix 1

2003 prey species survey (coastal coponent) of JARPN II

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ABSTRACT

A prey species survey was conducted concurrently with the sampling survey for minke whale by small-type whaling catcher boats in April 2003 as a part of coastal component of 2003 JARPN II. The primary objective of cooperative study was to estimate the prey preference of minke whale. While the whale sampling survey was conducted in the coastal waters within the 30 nautical miles (max 50 nautical miles) from Ayukawa, Miyagi prefecture, the prey species survey was conducted in wider area off Pacific side of the northern Honshu, Japan to cover the distribution of main prey species. The area was divided into inshore and offshore areas and zigzag track lines were set to cover the areas. The distribution and abundance of the prey species were investigated with the quantitative echosounder (EK60) on board a stern trawler-type research vessel, Kaiyo maru No. 7 (499.0 GT) steaming at about 10 knots along the track lines during daytime. Acoustic data were acquired with operating frequency at 38 and 120 kHz. Species compositions of acoustical backscatterings were identified by midwater trawl, IKMT and Bongo nets. In addition, trawl operations were made at predetermined stations. In the acoustic survey, Japanese anchovy and krill were found in the southern inshore area. Krill and adult sand lance were found in Sendai Bay where sampling survey for minke whales was concentrated. Sand lance was confined to the hard sea bottom. The area with hard sea bottom is limited to the southern part of Sendai Bay at depths of 30-100 m where many fishing vessels targeting to adult sand lance were operated. Only relatively strong echoes from plankton were observed in the northern inshore area. In the offshore area, weak echoes were found in the southern and northern parts, due to the strong effect of Kuroshio and Oyashio currents, respectively.

INTRODUCTION

The overall 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 preferences of cetaceans and ecosystem modeling. As it is difficult to cover the coastal area, especially in spring and autumn, by the Nisshin

Maru fleet, the full-scale JARPN II has a new coastal component, that is, the sampling survey for minke whale by small-type whaling catcher boats. As in 2002 surveys, a prey species survey was conducted concurrently with the coastal sampling survey during spring 2003 before the offshore surveys. In this document, the results of the 2003 prey species survey of the coastal component are presented.

MATERIALS AND METHOD

While the sampling survey of minke whale was conducted in the coastal waters within the 30 nautical miles (max 50 nautical miles) from Ayukawa, Miyagi prefecture, the prey species survey was conducted in wider area off the Pacific coast of the northern Honshu, Japan to cover the distribution 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 two parts; coastal and offshore areas. A zigzag track line was set to cover each area. The prey species survey was conducted from April 9 to 28 consisting of two terms; the first from April 9 to 18 and the second from April 18 to 28. The distribution and abundance of the prey species were investigated with the quantitative echosounder (EK60), midwater trawl, Isaacs-kidd Midwater Trawl (IKMT) and Bongo net on board a stern trawler-type research vessel, Kaiyo maru No. 7 (499.0 GT) steaming at about 10 knots along the track lines. The survey was conducted during the daytime from an hour after sunrise to an hour before sunset (generally from 6:00 to 17:00). Oceanographic observations with CTD were conducted just before or after the sampling operation. Sighting survey was conducted on board Kyoshin Maru No. 2.

Acoustic data were acquired with Echoview Ver.3 (Sonar Data Co., Ltd.) with operating frequency at 38 and 120 kHz of the hull-mounted transducers. Calibrations were carried out off Ishinomaki, Sendai Bay (April 18 2003) using the copper sphere technique. The mid-water trawl net used had a mouth opening of about 30x30m and a 17.5mm liner cod end. The depth and the height of the mouth of the net were recorded with the small-type depth recorders. Towing speed of the trawl net was 3-5 knots. Two types of mid-water trawlings were made. Targeting trawlings were to identify the species and size compositions of biological backscatterings detected by the echosounder. Samples were identified to the species level and weighed aboard the ship. For the major species, a sample of about 100 animals was taken and the lengths were measured to cm below. Some frozen samples were taken for further analysis in the laboratory. Also, IKMT was used to the biological backscatterings expected as micronekton and/or zooplankton such as krills on the echosounder. Bong net was also used to sample zooplankton. Samples were preserved in 10 % formalin for species identification at the laboratory. Another type of trawlings were made at predetermined stations to estimate the abundance and distribution of cephalopods and neustnic organisms that are difficult to detect with the echosounder. At predetermined stations the midwater trawl net was towed in a stairs-like fashion at three depth layer; 0-30m (surface) 30-60m and 60-90m. Towing duration was 30 minutes in total,

10 minutes for each layer. Samples taken were processed as in the targeting trawlings.

Acoustic data are being analysed at the laboratory. The analysed depth range was from the surface to 200m. Data collected at 38 kHz and 120 kHz were used mainly for fishes and krills, respectively. In principle, backscatterings on the echosounder were identified based mainly on the results of trawl and IKMT samplings. The school shape and backscattering intensity were also used for species identification. Backscatterings were identified as krills if ΔSv (the difference of Sv between 38 and 120 kHz) falls between 10 and 15 dB (Miyashita et al. 1997). The integration was made at an interval of one nautical mile by 50 m depth zone.

RESULTS

The planned track lines were almost covered in the acoustic survey. A summary of the midwater trawl, IKMT and Bongo net operations was shown on Table 1. The positions of midwater trawl, IKMT and Bong net operations were shown in Fig. 2. Targeting trawlings and IKMT were made 6 and 17 times, respectively. The midwater trawl operations were made at 14 predetermined stations. At the two stations among them, midwater trawl operations were made at night. Bong net operations were made 4 times. While the vast acoustical data are being analyzing now, the preliminary results are as follows.

Large-sized Japanese anchovy were found at depths shallower than 30m in the southern inshore area except for the Kuroshio Extension area (Fig. 3). Also krill were widely distributed in shoals in the southern inshore area (Fig. 3). In Sendai Bay, where most of the sampling survey for minke whales was conducted, the echoes of krill were detected widely, and the echoes assumed as adult sand lance were found at the surface layer and on the bottom of the sea (Fig. 4). By the targeting trawls, the schools on the hard bottom were identified as adult sand lance. The area with hard bottom is limited to the southern part of Sendai Bay at depths of 30-100 m where many fishing vessels targeting to adult sand lance were operated. Only relatively strong echoes from plankton were observed in the northern inshore area. In the offshore area, weak echoes were found in the southern and northern parts, due to the strong effect of Kuroshio and Oyashio currents, respectively. The prey preference of minke whale will be analyzed comprehensively based on the distribution and abundance of prey from the prey species survey and the diet composition from the whale sampling survey.

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Table 1. Midwater trawl, IKMT and Bongo net operations

St	Date			Gear	Target/ Prede.	Dura. (min.)	Depth (m)	Casting Time	Latitude		Longitude		SST (°C)
1	2003	4	10	Trawl	Prede.	30	0-100	11:37	35	27.4	141	21.9	–
2	2003	4	10	IKMT	Target	10	170-220	15:48	35	37.1	141	13.9	18.3
3	2003	4	11	Trawl	Prede.	60	0-100	8:01	35	56.9	140	58.4	14.0
4	2003	4	11	Trawl	Target	20	30-60	13:36	36	29.7	141	21.8	15.1
5	2003	4	12	Trawl	Prede.	60	0-100	7:08	37	00.2	141	55.0	8.7
6	2003	4	12	IKMT	Target	21	0-130	10:53	37	11.4	141	31.9	8.5
7	2003	4	12	IKMT	Target	30	0-100	12:58	37	18.9	141	15.8	8.6
7	2003	4	12	Trawl	Prede.	30	0-100	14:24	37	19.9	141	20.3	8.4
7	2003	4	12	Bongo	Target	–	0-100	16:17	37	19.6	141	14.0	8.8
8	2003	4	13	IKMT	Target	10	120-130	9:17	37	20.0	142	07.8	8.8
9	2003	4	13	Trawl	Prede.	30	0-100	12:33	37	32.2	141	53.7	6.6
10	2003	4	13	Bongo	Target	–	0-100	16:01	37	46.8	141	29.3	8.5
11	2003	4	14	Trawl	Target	8	0-30	7:12	37	52.1	141	20.2	8.5
12	2003	4	14	IKMT	Target	30	0-30	8:59	38	00.6	141	07.6	9.1
12	2003	4	14	Bongo	Target	–	0-30	9:51	38	02.2	141	07.8	9.0
13-1	2003	4	14	IKMT	Target	30	70-80	12:01	38	09.7	141	24.0	9.6
13-2	2003	4	14	IKMT	Target	20	60-70	13:26	38	09.9	141	24.1	9.7
14	2003	4	15	Trawl	Target	20	0-30	10:40	37	53.6	141	16.3	8.8
15	2003	4	15	Trawl	Target	20	30-60	11:36	37	53.7	141	18.3	8.8
16	2003	4	15	Trawl	Target	20	30-60	16:06	38	09.0	141	22.8	9.1
17	2003	4	16	Trawl	Target	37	30-60	8:01	37	54.3	141	19.8	9.0
18	2003	4	16	Trawl	Prede.	30	0-100	15:52	38	00.3	141	19.8	5.2
19	2003	4	17	IKMT	Target	30	0-100	8:17	38	17.6	142	20.3	3.2
20	2003	4	17	IKMT	Target	30	150-160	12:04	38	36.1	141	51.7	6.6
21	2003	4	19	Trawl	Prede.	30	0-100	7:07	38	39.9	142	59.8	4.8
22	2003	4	19	Bongo	Target	–	50-60	10:31	38	54.9	142	40.8	4.6
23	2003	4	19	IKMT	Target	25	70-80	14:44	39	17.1	142	16.4	3.5
24	2003	4	20	IKMT	Target	30	50-70	8:16	39	49.4	142	50.1	4.8
25	2003	4	20	IKMT	Target	20	60-70	13:15	40	19.0	143	01.4	10.4
26	2003	4	20	Trawl	Prede.	30	0-100	16:06	40	35.9	142	31.5	10.2
27	2003	4	21	Trawl	Prede.	30	0-100	6:57	40	27.3	143	21.2	2.4
28	2003	4	22	IKMT	Target	–	0-100	8:08	39	59.3	143	50.2	5.2
29	2003	4	22	IKMT	Target	–	40-60	12:32	39	31.9	143	50.5	8.3
30	2003	4	22	Trawl	Prede.	30	0-100	15:43	39	05.2	143	35.5	10.0
31	2003	4	23	IKMT	Target	16	50-70	7:58	38	46.3	143	25.2	5.7
32	2003	4	23	IKMT	Target	15	50-60	11:57	38	16.6	143	08.9	4.9
33	2003	4	23	Trawl	Prede.	30	0-100	15:45	37	47.5	142	53.4	4.2
33N	2003	4	23	Trawl	Prede.	30	0-100	19:11	37	48.2	142	53.2	4.1
34	2003	4	25	IKMT	Target	20	0-100	7:03	36	52.6	142	26.0	18.6
35	2003	4	25	Trawl	Prede.	30	0-100	12:03	36	10.4	142	04.8	16.6
36	2003	4	25	Trawl	Prede.	30	0-100	16:03	35	44.0	142	13.8	20.2
36N	2003	4	25	Trawl	Prede.	30	0-100	19:08	35	43.9	142	13.7	20.7
37	2003	4	27	Trawl	Prede.	30	0-100	10:23	35	02.8	142	34.7	21.0

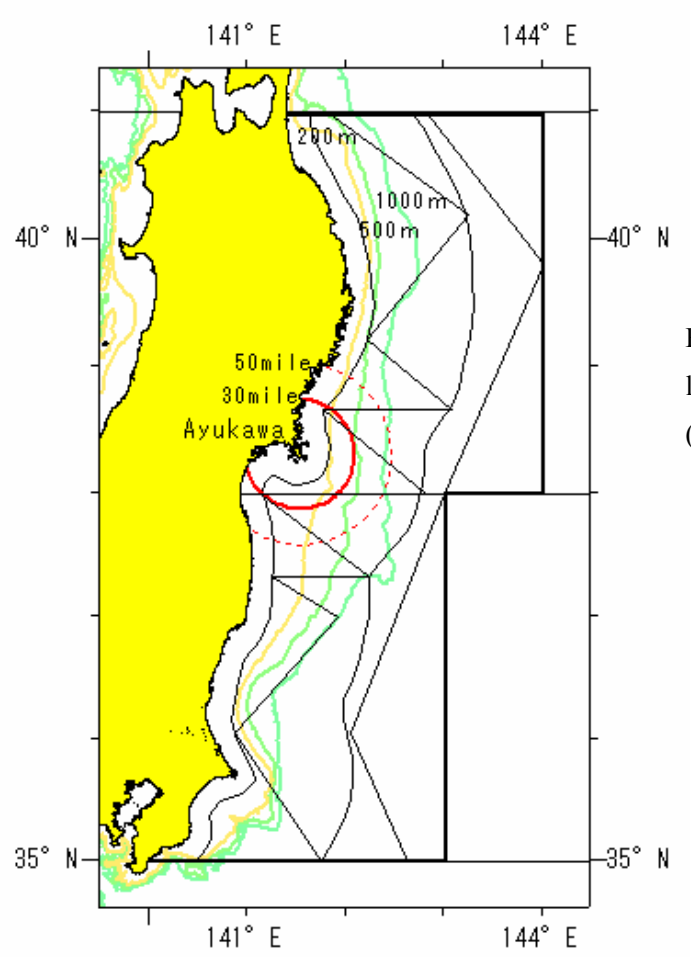

Fig. 1. The survey area and track lines for 2003 prey species survey (coastal component).

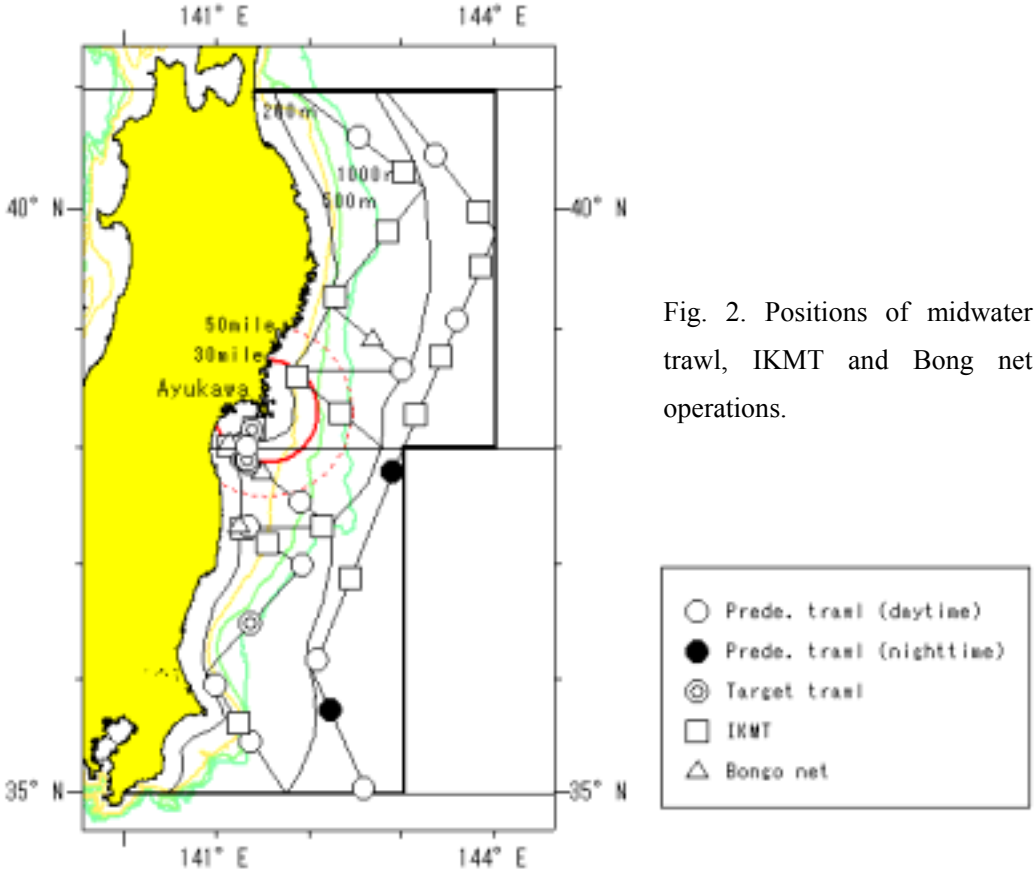

Fig. 2. Positions of midwater trawl, IKMT and Bong net operations.

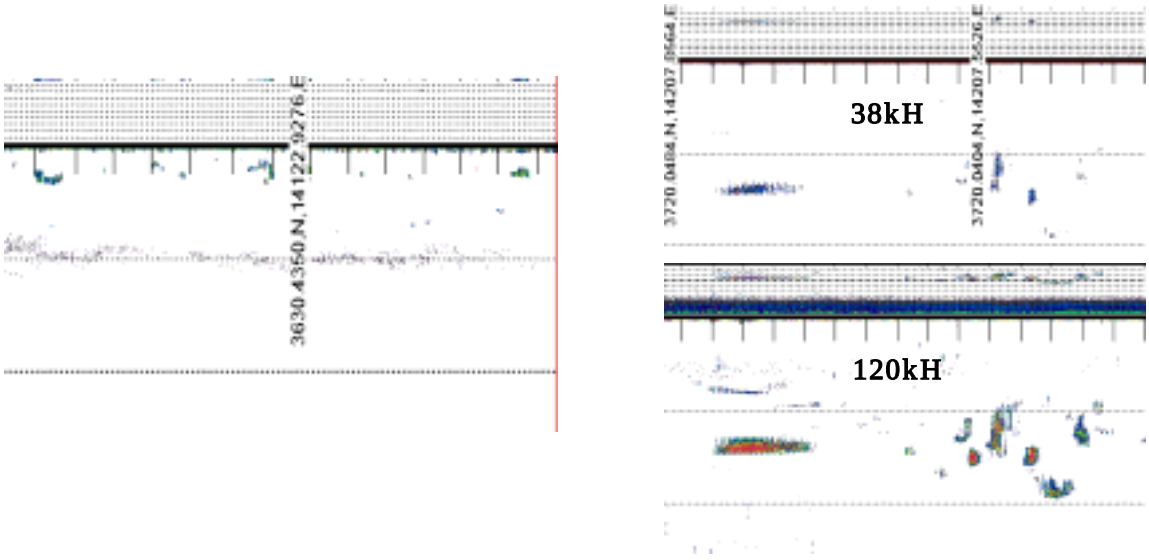

Fig. 3. Japanese anchovy (left) and krill (right) on the echo diagram in the southern inshore area.

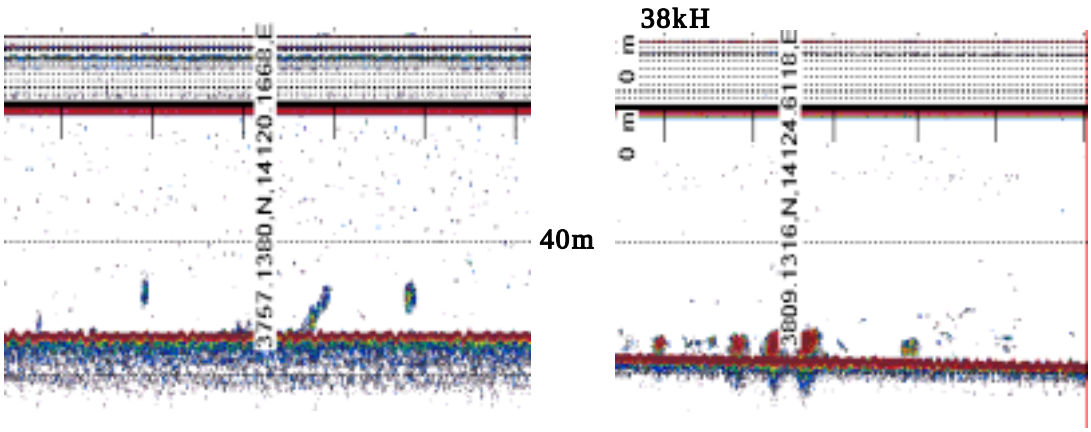

Fig. 4. Sand lance (left) and anchovy (right) on the echo diagram in Sendai Bay.

Appendix 2

Oceanographic conditions in the Kuroshio-Oyashio Inter-frontal zone in April 2003

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1. Introduction

The oceanographic condition at the Tohoku area east of Japan is the most complicated area in the world. There are both of subtropical water (the Kuroshio water) and subarctic water (the Oyashio water), and also, both water masses are mixed each other and form new water masses in the Kuroshio-Oyashio Inter-frontal Zone. Each water mass has its own ecosystem, like a Kuroshio ecosystem, an Oyashio ecosystem, warm-core ring ecosystem, etc. So, we must make clear the oceanographic condition around whale's prey to build up a marine ecosystem model in the Tohoku area.

In this paper, we analyzed the CTD data, which were observed by *Dai 7 Kaiyo Maru* cruise in the JARPNII (Japan's whale Research Program in the Western North Pacific) to make clear the oceanic environment in the research area.

2. Data and Methods

Hydrographic observations with a conductivity-temperature-depth profiler (CTD; SBE 19plus SEACAT Profiler) were carried out from 10th to 24th April 2003 in the Kuroshio-Oyashio Inter-frontal Zone using *Dai 7 Kaiyo Maru,* chartered by the Institute of Cetacean Research (Fig. 1).

The oceanographic conditions in April 2003 were analyzed by Tohoku National Fisheries Research Institute (TNFRI), which used quasi-real-time data from several cooperative organizations and prefectures, that was Fisheries Research Agency, Meteorological Agency, Hydrographic Department and Fisheries Experiment Stations, etc. TNFRI published temperature maps and schematic hydrographic maps using World Wide Web (http://www.myg.affrc.go.jp/index-j.html). Oceanic fronts and water masses are usually detected by subsurface temperature map (sea Table 1), because they are obscure in sea surface temperature distributions in summer seasons and the Oyashio water spreads into the subsurface layer.

3. Oceanographic conditions in the research area

Figure 2 shows the Temperature-Salinity diagrams using CTD station data. Water masses in the research area have characteristics of cold low-salinity water (the Oyashio water in the lower part of Fig. 2), warm high-salinity water (Kuroshio water in the right part of Fig.2) and the mixed water of the Kuroshio water and Oyashio water. In this figure, the Oyashio water (blue points in Fig. 2) was the most dominant although the Kuroshio water (red points in Fig. 2) was observed only one station.

Figure 3 shows the schematic hydrographic map in April 2003, presented by TNFRI. The northern limit of the Kuroshio Extension at the first crest was around 36°N (lower red area in Fig. 3), which is nearby 1σ south of the mean location. The northern limit of the warm water spread from the Kuroshio Extension shifts northward from March to November. Its position in April 2003 was at 41°10'N on 147°E line. This northward speeding is developed well caused by the Kuroshio warm-core ring that is detected around 40°N, 145°30'E. Tsugaru warm water spread eastward to 142°50'E. The southern limit of the first Oyashio Intrusion was located 37°30'N on 142°30'E line, which were more southern position from monthly mean location. The southern limit of the second Oyashio Intrusion was around 39°N, 147°E which was a little northern position from the mean position. In July, it was obscure in Fig 3 but maybe existed around 39°30'N, 146°30'E, where was in a slightly south from the mean.

Figure 4 shows the 100 m depth temperature map observed by *Dai 7 kaiyo Maru*. The Kuroshio Extension, which defined by 14°C at the depth of 200 m, was observed in the southern edge of Fig. 4. The Oyashio water colder than 5°C at the depth of 100 m was spreading in the northern part of the observation area. The warm water spreading from the Kuroshio area was observed at a few stations in the southern part of this area. The cold water was observed at few stations between the Oyashio water and the warm water spreading from the Kuroshio area.

Figure 5 shows the vertical temperature and salinity sections along approximately 141°E, 142°E and 143°E, which were zigzag lines. The warm water spread from the Kuroshio Extension was limited in the southern part of the 141°E and 143°E section although cold Oyashio water observed in the almost whole area, north of the warm water (north of 37°N). There was a sharp temperature front around 5°C to 10°C isotherms. 10°C isotherm is coincident with 34psu isohaline in each salinity section along 141°E and 143°E. In the North Pacific Ocean, 4°C isotherm (Subarctic Front) is the southern limit of the Subarctic water, and 34psu (Subtropical Boundary) isohaline indicates the north limit of the Subtropical water (Table 1). These fronts lie closely between subarctic water and Subtropical water in the research area but these fronts separate each other in the high sea of the North Pacific (see *Shunyo Maru* cruise report).

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Murakami, M. (1994): On long-term variations in hydrographic conditions in the Tohoku area, *Bull. Tohoku Natl. Fish. Res. Inst.*, No. 56, 47-56 (in Japanese with English abstract).

Table 1. Extraction method from temperature map to determine the position of each water mass.

Target characteristics	Extraction method
Kuroshio Extension Axis	14°C isotherm at 200m (Kawai, 1969)
Warm-core ring	Temperature front at 200m
Oyashio front	5°C isotherm at 100m
Oyashio water	Area with T<5°C at 100m
Cold water	Area with 5°C<T<10°C at 100m
Warm water	Area with T>10°C at 100m and T<14°C at 200m
Tsugaru warm current	Temperature front at 100m near the Tsugaru Strait
Subarctic Boundary	Salinity front defined by 34.0psu
Subarctic Front	Temperature front defined by 4°C

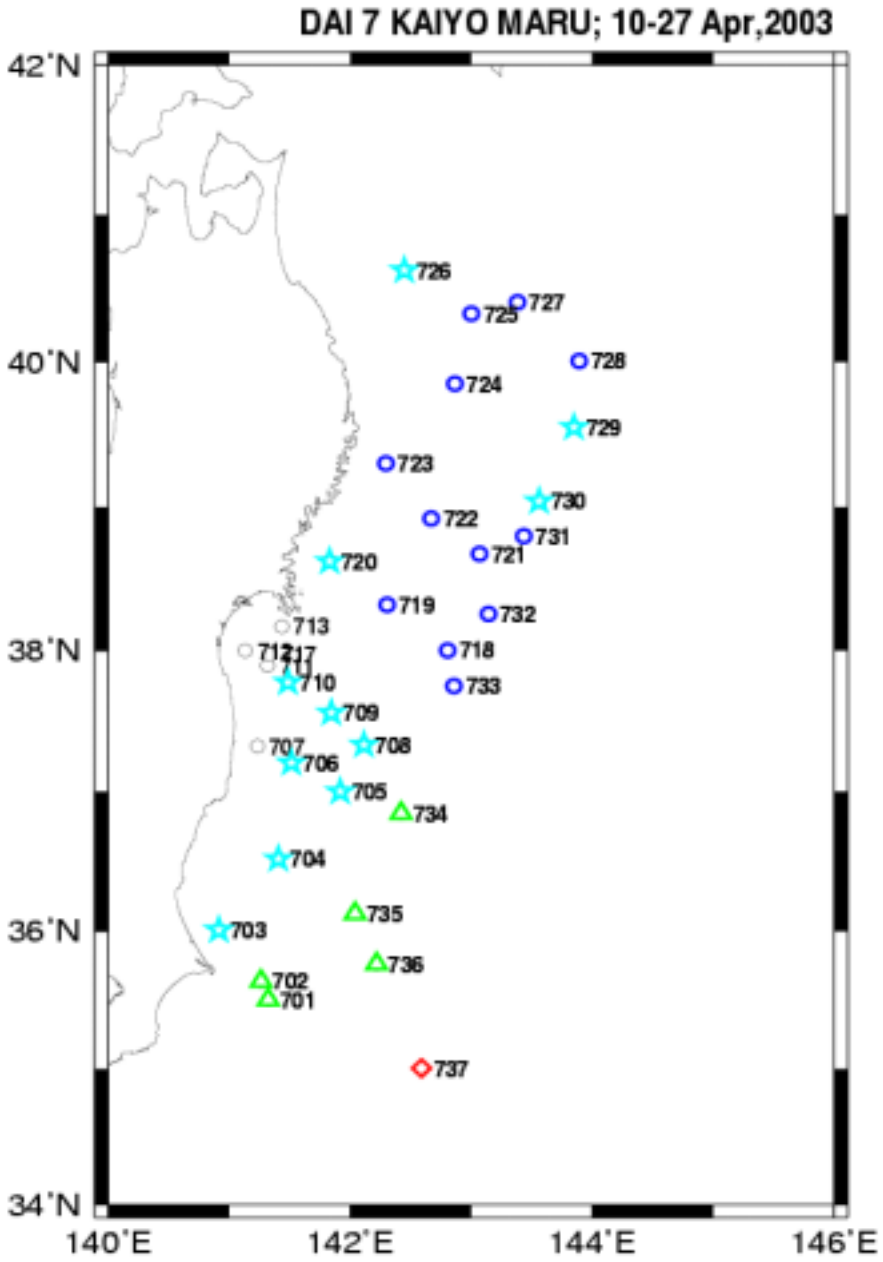

Fig. 1. Station map observed by *DAI 7 KAIYO Maru* in 10 – 27 April 2003. Green triangles, light blue stars and blue circles denote CTD stations in the warm area (100 m temperature was over 10°C and 200 m temperature was less than 14°C), the cold area (100 m temperature was over 5°C and less than 10°C) and the Oyashio area (100 m temperature was less than 5°C), respectively

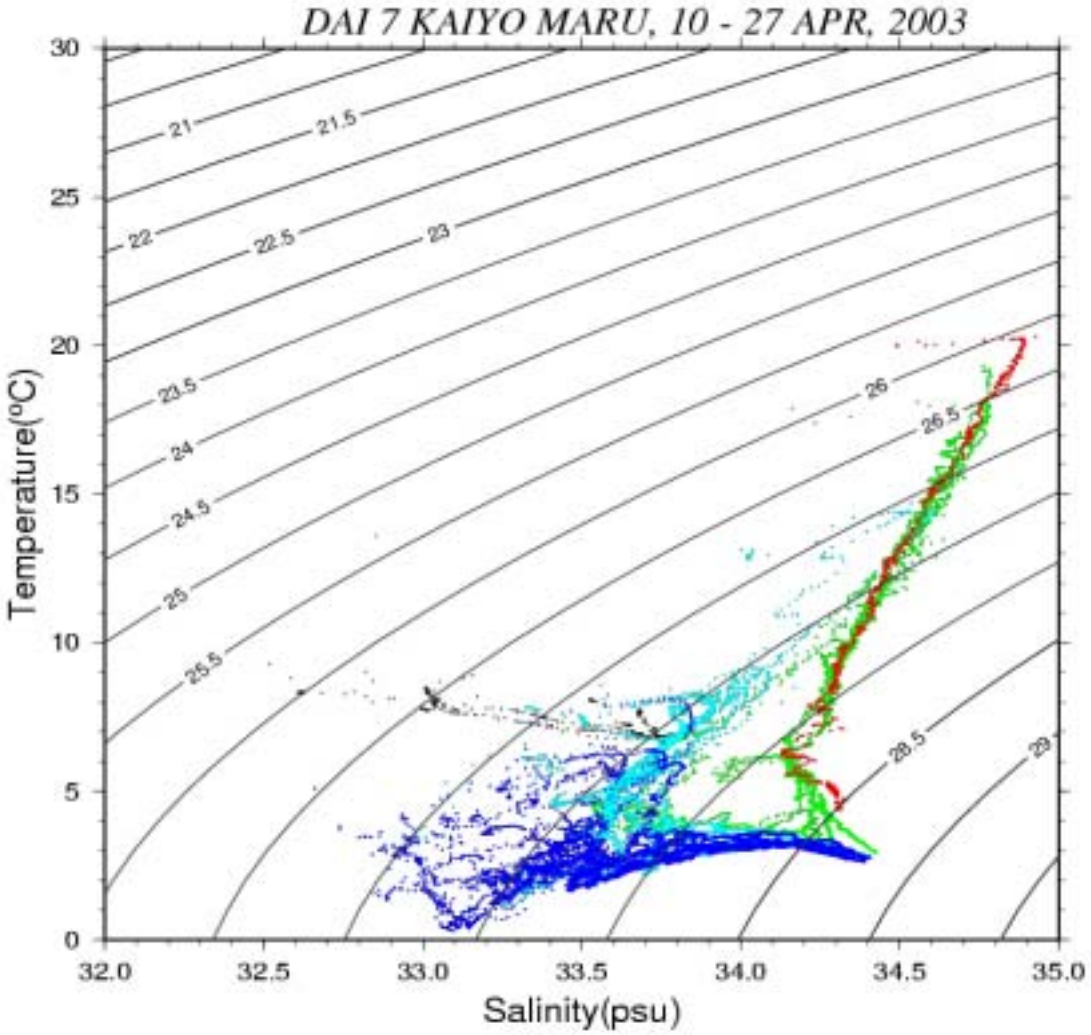

Fig. 2. Temperature-Salinity diagrams using CTD station data observe by *DAI 7 KAIYO Maru* in 10 – 27 April 2003. Each thin line in this figure denotes a density line of sigma-t. Red, green, light blue and blue points corresponded to the Kuroshio area, warm area, the cold area and the Oyashio area, respectively.

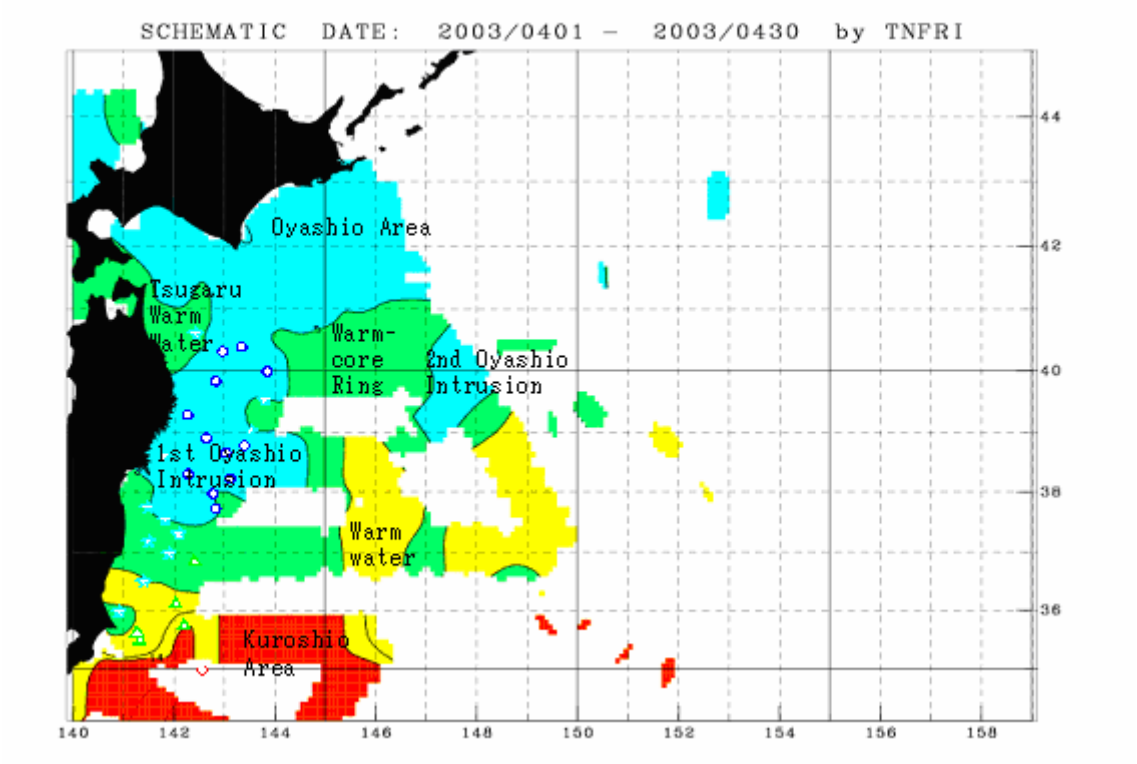

Fig. 3. Schematic hydrographic map in Tohoku area, northwestern Pacific, in 2002. (Presented by Tohoku National Research Institute.) Blue area, green area, yellow area and red area denote the Oyashio (100 m temperature was less than 5°C), cold area (100 m temperature was over 5°C and less than 10°C), warm water (100 m temperature was over 10°C and 200 m temperature was less than 14°C) spreading from the Kuroshio Extension and the Kuroshio area (200 m temperature was over 14°C), respectively. Red diamond, green triangles, light blue stars and blue circles denote CTD stations observed by *DAI 7 KAIYO Maru* in the Kuroshio area, warm area, cold area and the Oyashio area, respectively

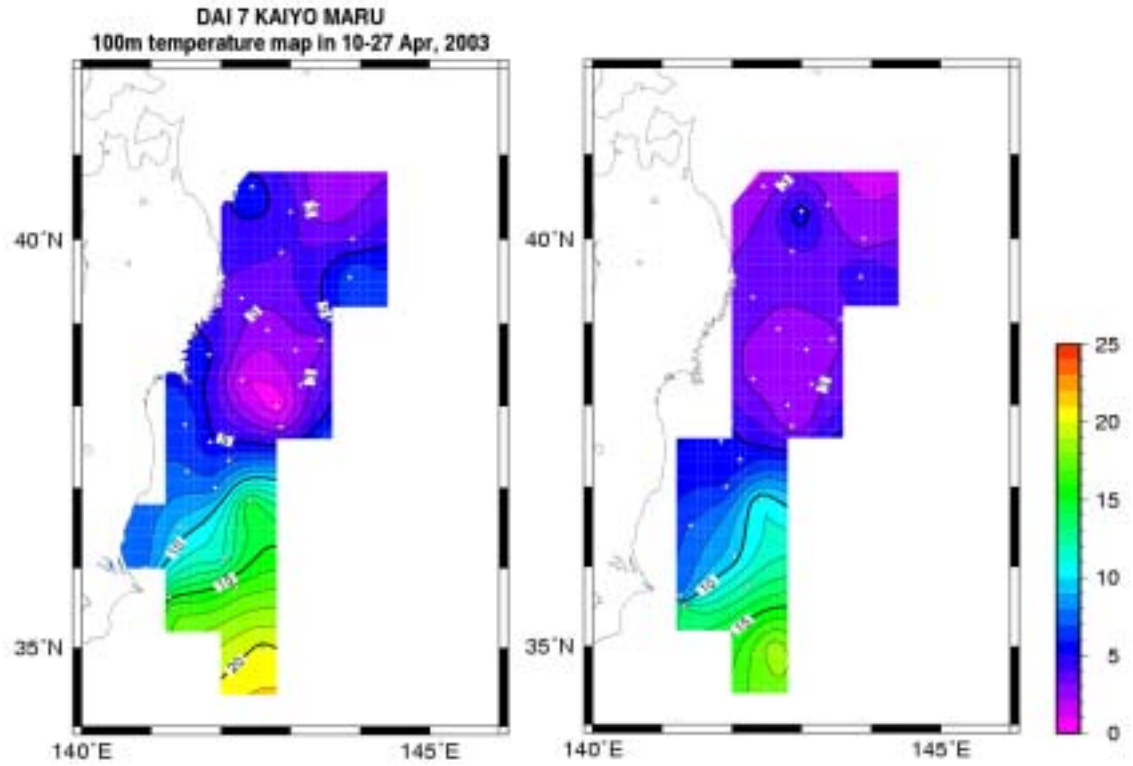

Fig.4. 100m temperature (upper left panel) and 200m temperature (lower panel) maps observed by *DAI 7 KAIYO Maru* in 10 – 27 April 2003.

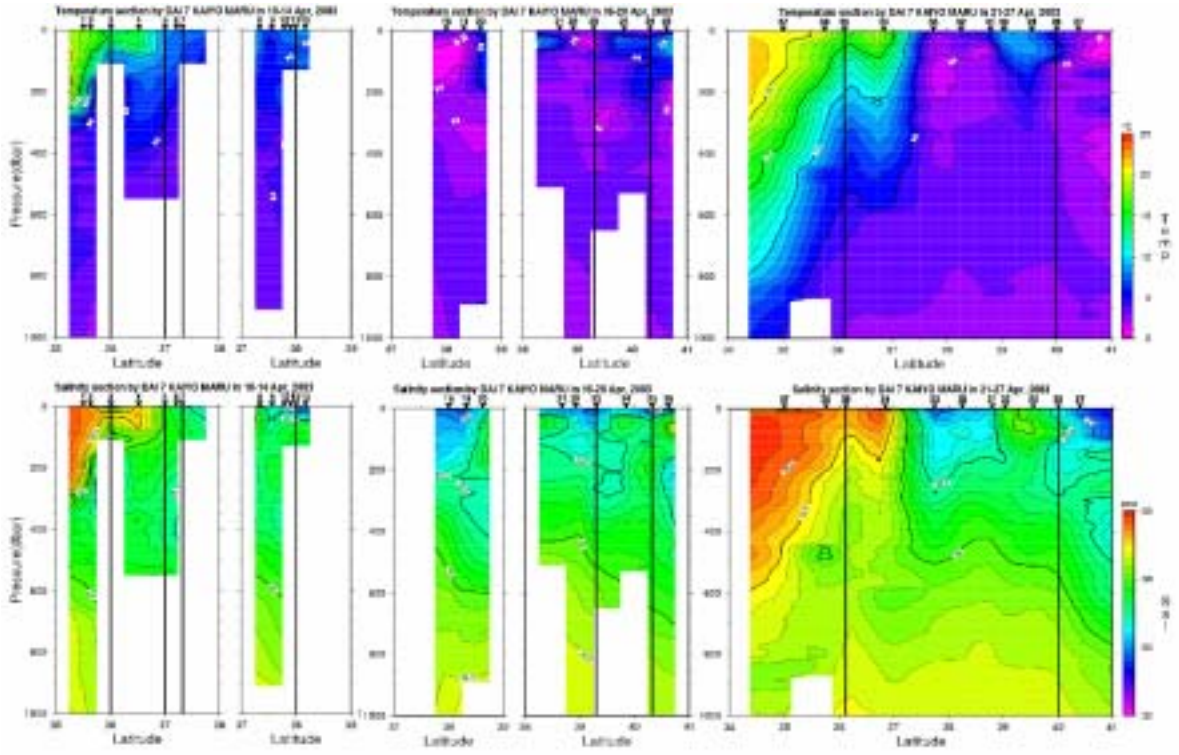

Fig. 5. Temperature (upper panels) and salinity (lower panels) along approximately 141°E(left panels), 142°E (middle panels) and 143°E (right panels) observed by *DAI 7 KAIYO Maru* in 10 – 27 April 2003.

Appendix 3

Cruise report of the dedicated sighting survey in 2003 JARPNII coastal survey off Sanriku, northeast Japan

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ABSTRACT

A cetacean sighting survey using the line transect method was conducted concurrently with the whale sampling survey and the whale prey survey off the Sanriku coast, Japan from 8 to 28 April. The primary objective of the sighting survey was the abundance estimation of baleen whales in the survey area. *Shonan-maru* was dedicated to the sighting survey. Total primary searching distance was 1,086.7 n. miles and the 129 schools (534 individuals) of primary sightings were made.

INTRODUCITON

A cetacean sighting survey using the line transect method was conducted concurrently with the whale sampling survey and the whale prey survey off the Sanriku coast, Japan from 8 to 28 April, as a part of coastal component of 2002 JARPN II full scale study (Government of Japan, 2002). The primary objective of this survey was to obtain information on abundance of baleen whales in the survey area. Preliminary results of the cetacean sighting survey are presented in this paper.

MATERIALS AND METHODS

The cetacean sighting survey area was set within Sub-area 7 (Fig. 1). Though the sampling of whales was conducted within the 30 n. miles from Ayukawa port in the Sanriki, sighting survey area had larger are extent to see the overall baleen whale distribution pattern off the coast of the Sanriku. Near shore area of the survey block where the water depth is less than 50m was not surveyed because many fisheries gears were set in there. The survey block was further divided into the coastal and offshore area. Coastal area was divided into three at the two boundary lines, 37ºN and 39ºN. Offshore area was divided into two at the boundary lines on 38ºN. The survey was conducted from 9 to 28, 2003. *Shonan-maru*(SM1, 712GT) engaged in the cetacean sighting survey. Sighting survey procedures were same as offshore component of 2003 JARPN II. The right (*Eubalaena japonica*),

blue (*Balaenoptera musculus*), and humpback (*Megaptera novaeangliae*) whales can be approached to obtain the Natural marking record experiments as the opportunistic basis. Large baleen whale feeding behavior visual observation was attempted. If the behavior was observed, it was recorded on video tape.

RESULTS AND DISCUSSION

Tracklines surveyed are shown in Fig. 1 (right). Total primary searching distance was 1,086.7 n.miles. The 129 schools (534 individuals) of primary sightings were obtained and one secondary sighting (one animal/one school) was also made. Details of sightings are listed in Table 1. Sightings of common minke, fin, right, and sperm whales were recorded. Sighting positions of the first three species are noted in the Fig. 2 (right). Natural marking record experiments were conducted on a right whale and two humpback whales. No feeding behavior of large baleen whales was observed.

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Table 1. Summary of cetacean sightings made during the dedicated sighting survey in 2003 JARPNII coastal survey.

Species	Primary		Secondary	
	Sch.	Ind.	Sch.	Ind.
Common minke whale	3	3	1	1
Fin whale	1	1	0	0
Humpback whale	1	2	0	0
Right whale	1	1	0	0
Sperm whale	8	35	0	0
Unidentified large whale	1	1	0	0
Unidentified cetaceans	2	2	0	0

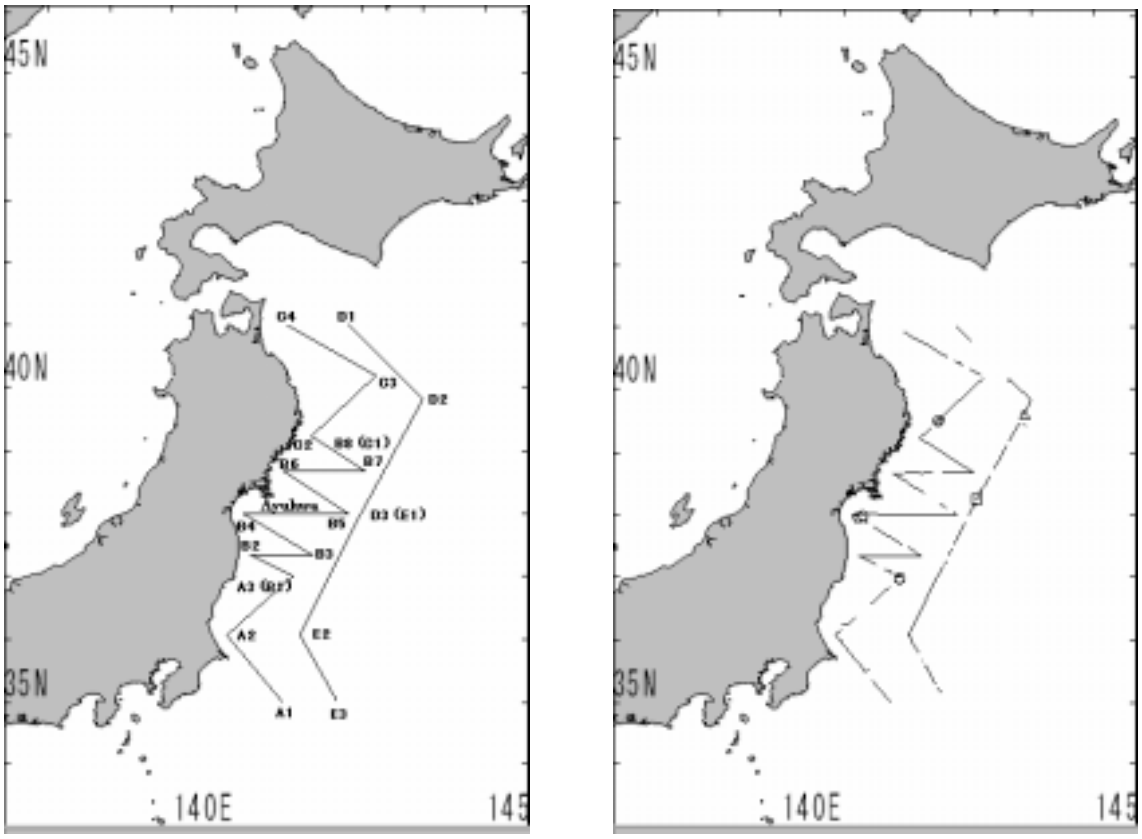

Fig. 1. Survey area and predetermined tracklines (left), and surveyed tracklines and sighting positions of common minke (open circle), fin (open triangle), right (double circle) and humpback (open square) whales (right), during the dedicated sighting survey in 2003 JARPNII coastal survey.