Cruise Report of the Second Phase of the Japanese Whale Research Program under Special Permit in the Western North Pacific (JARPN II) in 2008 - (Part II) - Coastal component off Sanriku

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ABSTRACT

The 2008 survey of the JARPN II coastal component off Sanriku (northeastern Japan, corresponding to a part of sub-area 7), was conducted from 14 April to 18 May, using four small-type whaling catcher boats and one echo sounder trawl survey vessel. Sampling of common minke whales was conducted in coastal waters within 50n. miles from Ayukawa port in the Sanriku district, and all animals collected were landed on the JARPN II research station established for biological examination. A total of 5,275.9n.miles (482.0 hours) was surveyed and 94 schools (96 individuals) of common minke whales were sighted. A total of 60 animals were sampled. Average body length of the animals was 5.67m (SD: 1.06, *n*=23) for males and 5.91m (SD: 1.01, *n*=37) for females. Dominant prey species found in the forestomach were adult and juvenile of Japanese sand lance (*Ammodytes personatus*) throughout all survey period. Japanese anchovy (*Engraulis japonicus*) and krill (*Euphausia pacifica*) were observed from one individual each, respectively. Juvenile of the Japanese sand lance in the stomach of minke whales were observed for the first time in Sanriku. This result indicates 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 objectives of the program are to evaluate the feeding ecology and ecosystem studies, involving prey consumption by cetaceans, prey preferences of cetaceans and ecosystem studies, to monitor environmental pollutants in cetaceans and the marine ecosystem and 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 autumn 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, 2004a, 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, 2004b). The revised survey off Sanriku was carried out in spring 2005 (Yoshida *et al*., 2006), 2006 (Goto *et al*., 2007) and 2007 (Bando *et al*., 2008).

In the present paper, we show results of the fourth survey carried out in coastal waters off the Sanriku district, Japan, from 14 April to 18 May in 2008. 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 Technology Institute.

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; Bando *et al.*, 2008). 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 considered 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 14 April to 18 May, 2008. 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 25 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.

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 5275.9 n. miles and 482.0 hours, respectively (Table 1).

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 94 schools (96 individuals) of common minke whales were sighted. These were 83 primary sightings (85 animals) and 11 secondary sightings (11 animals). Of 94 schools sighted, only 2 schools consisted of 2 individuals and others were solitary animals. Cow-calf pairs were not 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 the first period through the research period.

Sampling of common minke whales

A total of 60 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. 3.

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 60 animals consisted of 23 males and 37 females. Sex ratio of males to all animals was 0.38.

Average body length was 5.67m (max=7.78, min=4.07, SD: 1.06) for males and 5.91m (max=8.12, min=4.13, SD=1.01) for females, respectively (Table 5). Frequency of body length of common minke whale by sex was shown in Fig. 4. Average body lengths of both male and female in the second period were higher than those in the first and third periods.

Composition of sexual maturity of animals collected is listed in Table 6. In males, 4 of 23 animals were sexually mature (17.0%), and 7 of 37 females attained sexual maturity (22.2%). 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 7. Dominant prey species were adult and juvenile Japanese sand lance (*Ammodytes personatus*) (95.8%, 47 from 49 animals). The adults, juveniles and mix of them were observed in 32, 11 and 4 animals, respectively. Japanese anchovy (*Engraulis japonicus*) and krill (*Euphausia pacifica)* were observed in each one animal in the research period.

The maximum net weight of forestomach contents was 77.4 kg, of which consisted adult of Japanese sand lance (Table 8). This individual was female with body length of 6.19m and body weight of 2.43 tons. Forestomach contents weight was 3.19 % of her body weight.

DISCUSSION

The present survey was the fifth 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.

The minke whales collected in the second period (1-14 May) were distributed in the southern Sendai Bay, while those in first (14-30 April) and third (15-18 May) period were widely distributed at the center of the Sendai Bay (Fig. 3). And also, the maturity ratios of minke whales in both sexes collected in the second period were comparatively higher than those in first and third periods (Table 6). The results indicate seasonal change of migration pattern in the minke whales in the Sendai Bay.

Dominant prey species found from forestomach of animals were adult and juvenile of Japanese sand lance throughout survey period (Table 7). Japanese anchovy and krill were observed from only one individual, respectively.

In the 2003 coastal survey off Sanriku, adult of Japanese sand lance and krill had mainly been observed in the stomach contents of minke whales (Yoshida, *et al*. 2004). And also, adult of Japanese sand lance and Japanese anchovy had mainly been observed in the 2005, 2006 and 2007 surveys (Yoshida *et al*.,

2006; Goto *et al.*, 2007; Bando *et al.*, 2008). However, either adult or juvenile, or both of them were observed in those of almost all minke whales in the present season. Furthermore, juvenile of Japanese sand lance was for the first time observed in JARPN II Coastal component off Sanriku. These indicate that feeding habit of the minke whales in coastal waters off Sanriku changes year by year.

From the present survey, we could obtain valuable information for 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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Table 1. Searching days, hours, distances by four sampling vessels in the 2008 JARPN II coastal surveys off Sanriku.

Period		Sampling vessels*				Total
		28T	75K	07K	31S	
First period	Days	11	11	11	11	44
(14-30 April)	Hours	57.5	75.9	73.1	70.5	277.0
	Distances (n. mile)	643.4	818.5	772.3	773.3	3030.4
Second period	Days	9	8	8	8	33
(1-14 May)	Hours	34.3	36.1	33.0	28.4	131.8
	Distances (n. mile)	383.9	396.9	350.1	296.8	1441.6
Third period	Days	3	4	3	3	13
(15-18 May)	Hours	20.4	20.0	20.1	12.9	73.2
	Distances (n. mile)	230.5	218.8	216.1	141.4	804.0
Total	Days	23	23	22	22	90
	Hours	112.1	131.9	126.2	111.8	482.0
	Distances (n. mile)	1257.8	1457.1	1338.5	1208.5	5275.9

*: 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 2008 JARPN II coastal surveys off Sanriku.

Period	Species	Primary		Secondary		Total	
		Sch.	Ind.	Sch.	Ind.	Sch.	Ind.
First period	Common minke whale	54	54	9	9	63	63
(14-30 April)	Like minke whale	25	25	3	3	28	28
Second period	Common minke whale	16	16	1	1	17	17
(1-14May)	Like minke whale	26	2	1	1	3	3
Third period	Common minke whale	13	15	1	1	14	16
(15-18 May)	Like minke whale	6	6	0	0	6	6
Total	Common minke whale	83	85	11	11	94	96
	Like minke whale	33	33	4	4	37	37

Table 3. Density index of common minke whales by sampling vessels in the 2008 JARPN II coastal survey off Sanriku.

Period	SPUE*1	DI*2
First period (14-30 April)	0.19	1.78
Second period (1-14 May)	0.08	1.11
Third period (15-18 May)	0.16	1.62
Total	0.12	1.61

*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 2008 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	23	37	60
External body proportion	23	37	60
Photographic record and external character	23	37	60
Diatom film record	23	37	60
Body scar record	23	37	60
Measurements of blubber thickness (5 points)	23	37	60
Detailed measurements of blubber thickness (11 points)	1	4	5
Body weight	23	37	60
Body weight by parts	1	4	5
Skin tissues for DNA study	23	37	60
Muscle, liver, kidney, spleen, blubber, heart and ventral groove for various analysis	23	37	60
Urine for various analysis	8	3	11
Muscle, liver, kidney, and blubber for heavy metal analysis	23	37	60
Muscle, liver, kidney, and blubber for organochlorine analysis	23	37	60
Collection of blood plasma	20	25	45
Muscle and vertebra for lipid analysis	1	4	5
Mammary grand; lactation status, measurement and histological sample	-	37	37
Uterine horn; measurements and endometrium sample	-	37	37
Collection of Ovary	-	37	37
Photographic record of fetus	3	2	7*
Fetal length and weight	3	2	5
External measurement of fetus	3	2	5
Muscle, liver, kidney, heart, blubber and skin tissues of fetus	3	2	5
Collection of fetus	0	0	2*
Testis and epididymis; weight and histological sample	23	-	21
Stomach contents, convenient record	23	37	60
Volume and weight of stomach content in each compartment	23	37	60
Observation of marine debris in stomach	23	37	60
Stomach contents for feeding study	19	33	52
Record of external parasites	23	37	60
Earplug for age determination	23	37	60
Tympanic bulla for age determination	23	37	60
Eye lens for age determination	23	37	60
Largest baleen plate for morphologic study and age determination	23	37	60
Baleen plate measurements (length and breadth)	23	37	60
Photographic record of baleen plate series	23	37	60
Length of baleen series	23	37	60
Vertebral epiphyses sample	23	37	60
Number of ribs	23	37	60
Skull measurement (length and breadth)	23	37	60

*: including a fetus of sex unidentified.

Table 5. Statistics of body length (m) of common minke whales collected during the 2008 JARPN II coastal survey off Sanriku.

Period	Male					Female				
	mean	S.D.	Min.	Max.	n	mean	S.D.	Min.	Max.	n
First period (14-30 April)	5.38	0.79	4.07	6.66	12	5.98	0.94	4.13	7.74	25
Second period (1-14 May)	6.78	1.14	4.63	7.78	6	6.63	1.22	5.27	8.12	5
Third period (15-18 May)	5.06	0.56	4.42	5.90	5	5.13	0.72	4.32	6.15	7
Total	5.67	1.06	4.07	7.78	23	5.91	1.01	4.13	8.12	37

Table 6. Composition of sex and sexual maturity status of common minke whales collected by the 2008 JARPN II coastal survey off Sanriku.

Period	Male					Female						
	Im	M	Uk	Total	Maturity (%)	Imm.	R	P	P&L	Uk	Total	Maturity (%)
First period (14-30 April)	12	0	0	12	0.00	19	0	4	1	1	25	0.24
Second period (1-14 May)	2	4	0	6	0.67	3	0	2	0	0	5	0.40
Third period (15-18 May)	5	0	0	5	0.00	7	0	0	0	0	7	0.00
Total	19	4	0	23	0.17	29	0	6	1	1	37	0.22

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

Table 7. Prey species found in forestomach of common minke whales collected by the 2008 JARPN II coastal survey off Sanriku.

Period	Sample size	Prey species				
		Sand lance (adult)	Sand lance (juvenile)	Sand lance (adult+juvenile)	Japanese anchovy	Krill
First period	30	22	5	2		1
(14-30 April)	(%)	73.3	16.7	6.7		3.3
Second period	9	7	1	1		
(1-14 May)	(%)	77.8	11.1	11.1		
Third period	10	3	5	1	1	1
(15-18 May)	(%)	30.0	50.0	10.0	10.0	5.0
Total	49	32	11	4	1	1
	(%)	65.3	22.4	8.1	2.0	2.0

*: removing animals with broken stomach by harpoon.

Table 8. Weight (kg) of forestomach content of common minke whales collected by the 2008 JARPN II coastal survey of Sanriku.

		Sand lance			Japanese anchovy	Krill
		adult	juvenile	(adult+juvenile)		
First period	average	11.3	9.6	53.6		2.6
(14-30 April)	range	(1.6-77.4)	(2.5-33.4)	(50.8-56.3)		
Second period	average	15.4	27.9	36.1		
(1-14 May)	range	(2.2-48.5)				
Third period	Average	8.2	4.1	13.8	6.5	
(15-18 May)	range	(7.4-8.8)	(0.4-12.7)			
Total	Average	11.9	8.8	39.3	6.5	2.6
	range	(1.6-76.4)	(0.4-33.4)	(13.8-56.3)		

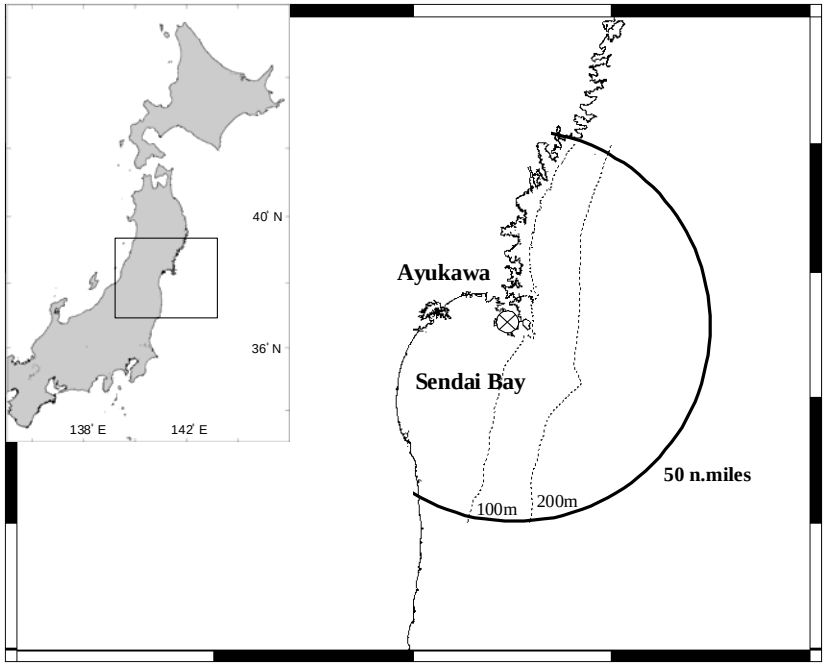

Fig. 1. Research area of the 2008 JARPNII coastal survey off Sanriku.

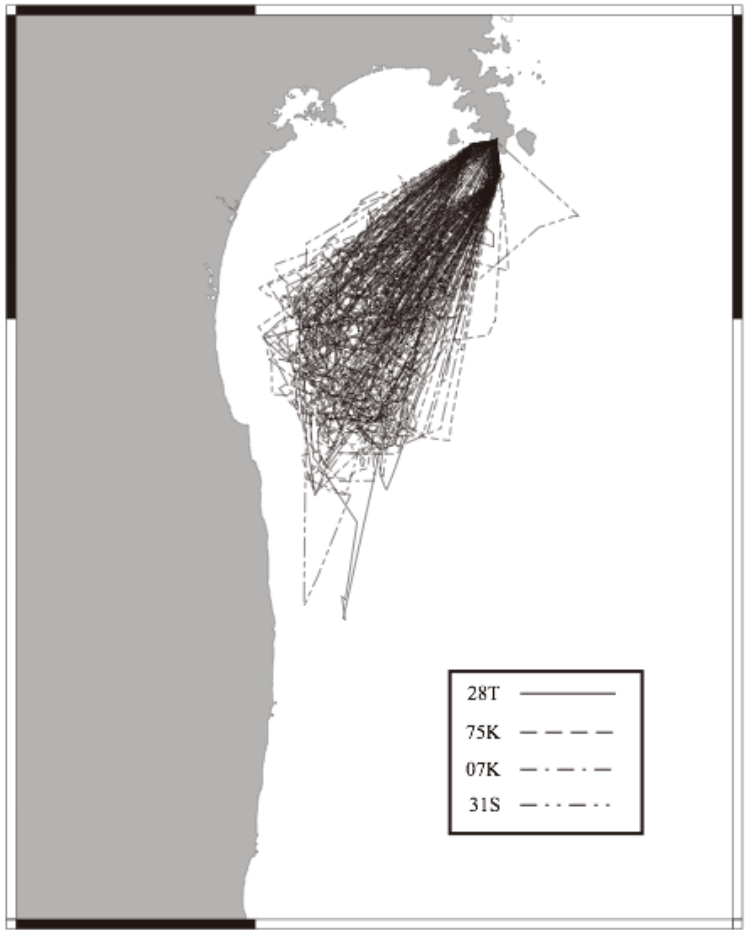

Fig. 2. Cruise trucks made by four sampling vessels in the 2008 JARPNII coastal survey off Sanriku.

Fig. 3. Sighting position of common minke whales made by sampling vessels in the 2008 JARPNII coastal survey off Sanriku (●: sighting and sampled; ○: only sighting).

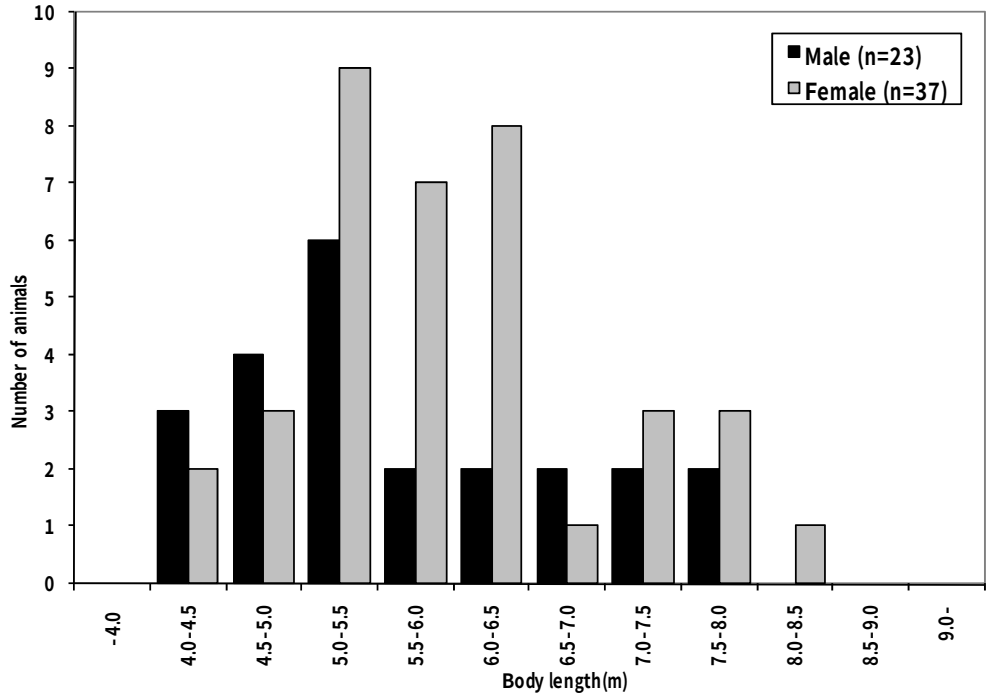

Fig. 4. Frequency of body length of common minke whales taken in the 2008 JARPNII coastal survey by sex.

Appendix 1

2008 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 in spring 2008 as a part of JARPNII coastal component off Sanriku. The survey was conducted concurrently with a sampling survey of common minke whales. The survey period was from 9 to 24 April. Five stratified blocks were surveyed. Zigzag tracklines were set in the blocks. A trawler type RV, Takuyo-maru, conducted the survey. Acoustic data were recorded continuously along tracklines by a quatitative echosounder. Samplings using a midwater trawl net were conducted at 9 stations to identify species and size compositions of acoustic backscatterings. Vertical oceanographic conditions were recorded at 29 stations by using a CTD. Subsurface oceanographic conditions were recorded continuously along tracklines.

INTRODUCTION

JARPN II is designed to contribute to conservation and sustainable use of marine living resources including whales in the western North Pacific, especially within Japan's EEZ (Government of Japan, 2002). One of the major objectives of JARPNII is to advance feeding ecology and ecosystem studies, involving studies of prey consumption by cetaceans, prey preference of cetaceans and ecosystem modeling. To accomplish the goal, sampling survey of common minke whales (*Balaenoptera acutorostrata*) and survey on biomass estimation of their prey species have been conducted concurrently off Sanriku, Japan since 2003 as a JARPNII coastal component. In this document, the results of the 2008 prey species survey off Sanriku are presented.

MATERIALS AND METHODS

While the sampling survey of minke whale was conducted in the coastal waters within the 50 n.miles (mainly within 30 n.miles) from Ayukawa, Miyagi prefecture, Japan, 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. Seven survey blocks (A-G) have been set within the survey block since 2005 for the purpose of biomass estimation of prey species based on a stratified random sampling method using echosoudner data (Fig 1a). Stratification of blocks was based on bottom depth (20, 40, 100, and 200m) and prefectural boundary (boundary between Miyagi and Fukushima prefecture). Because of logistical constraint, 5 blocks (B, C, E, D, E and F) were surveyed in 2008 (Fig. 1b). 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 24. The survey was conducted during the daytime from an hour after sunrise to an hour before sunset. Acoustic, trawl and oceanographic surveys were conducted using a

trawler-type RV, "Takuyo maru" (Miyagi prefecture, 120 GT). Data of distribution and abundance of the prey species were recorded by an EK 500 quantitative echosounder (Simrad, Norway) with operating frequency at 38, 120 and 200 kHz. The RV steamed at about 9-10 knots along the tracklines. Acoustic data were stored with an aid of software, Echoview (Sonar Data, Austlaria). A calibration was carried out in the survey area on (April 9 2008) using the copper sphere technique described in EK 500 manual. Vertical oceanographic observations were conducted with CTD. Subsurface (approximately 5m water depth) temperature, salinity and chlorophyll-a were recorded every minute (in time) along the tracklines.

Acoustic data were acquired with Echoview Ver.3 (Sonar Data Co., Ltd.). 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) by 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. Scale and standard lengths were used to anchovy (*Engraulis japonicus*) and sand lance (adult and juvenile, *Ammodytes personatus*), respectively. Total length from the tip of the rostrum to the end of the telson was used for krill (*Euphausia pacifica*). Some frozen samples were taken for further analysis in the laboratory.

RESULTS

The planned tracklines were almost surveyed by the quantitative echosounder. A summary of the midwater trawl operations, temperature by depth and catches was shown on Table 2. Trawl hauls were made at 9 stations. Because no adult sand lance was sampled in this survey, length frequency data were obtained from samples from a commercial catch. CTD casts were conducted at 29 stations. Continuous monitoring of subsurface temperature indicated that water temperature was colder than nominal years. Juvenile and adult sand lance was observed in Blocks B, C, E and F. In contrast to previous surveys, dense schools of juvenile sand lance were observed in those blocks. In the past surveys, schools of juvenile sand lance were mainly observed near surface layer. Amount of Commercial catch of juvenile sand lance during the survey period was significantly higher than 2007. Krill were observed near bottom in Blocks C and D. Few schools of Japanese anchovy were observed in Block F. Detailed analysis will be conducted in the laboratory and the results will be presented in the near future.

ACKNOWLEDGEMENT

We would like to thank the captain of RV "Takuyo-Maru", Mr. Hiroaki Kimura, and his crews who assisted us to collect a valuable data set. This survey was supported by Fisheries Agency of Japan, Fisheries Research Agency of Japan, Miyagi Prefecture and the Institute of Cetacean Research. We thank to these institutions for their support.

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Table 1. Waypoints and planed lines.

Block B

Waypoint	Latitude				Longitude				Course (degree)	Distance (n.mile)
B1	38	-	21.1	N	141	-	22.0	E	257	7.1
B2	38	-	19.5	N	141	-	13.2	E	124	6.3
B3	38	-	16.0	N	141	-	19.9	E	257	15.2
B4	38	-	12.5	N	141	-	01.1	E	106	12.5
B5	38	-	09.0	N	141	-	16.3	E	256	15.2
B6	38	-	05.4	N	140	-	57.5	E	104	14.2
B7	38	-	02.0	N	141	-	15.0	E	256	14.2
B8	37	-	58.5	N	140	-	57.5	E	107	12.0
B9	37	-	55.0	N	141	-	12.1	E	251	3.0
B10	37	-	54.0	N	141	-	08.5	E	-	-
									Total	99.8

Block C

Waypoint	Latitude				Longitude				Course (degree)	Distance (n.mile)
C1	38	-	15.0	N	141	-	36.9	E	262	17.5
C2	38	-	12.5	N	141	-	14.9	E	102	12.4
C3	38	-	10.0	N	141	-	30.3	E	257	11.4
C4	38	-	07.5	N	141	-	16.2	E	106	8.9
C5	38	-	05.0	N	141	-	27.1	E	255	9.9
C6	38	-	02.5	N	141	-	15.0	E	107	8.8
C7	37	-	60.0	N	141	-	25.6	E	256	9.7
C8	37	-	57.5	N	141	-	13.7	E	106	9.0
C9	37	-	55.0	N	141	-	24.6	E	256	4.2
C10	37	-	54.0	N	141	-	19.5	E	-	-
									Total	91.6

Block D

Waypoint	Latitude				Longitude				Course (degree)	Distance (n.mile)
D1	38	-	14.9	N	141	-	48.0	E	106	1.5
D2	38	-	14.5	N	141	-	49.8	E	254	15.9
D3	38	-	10.0	N	141	-	30.4	E	106	16.0
D4	38	-	05.5	N	141	-	49.9	E	257	19.4
D5	38	-	01.0	N	141	-	26.0	E	109	13.6
D6	37	-	56.5	N	141	-	42.3	E	274	8.1
D7	37	-	54.0	N	141	-	32.0	E	-	-
									Total	74.5

Block E

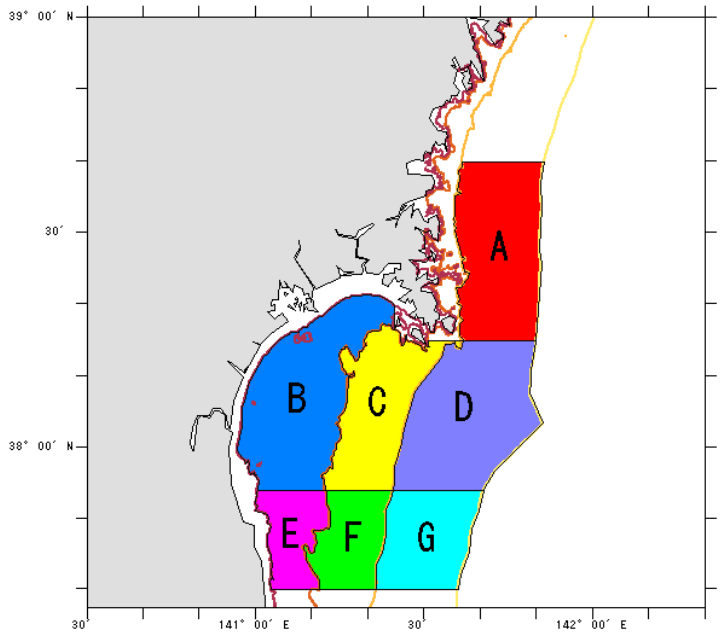
Waypoint	Latitude				Longitude				Course (degree)	Distance (n.mile)
E1	37	-	54.0	N	141	-	02.5	E	255	2.0
E2	37	-	53.5	N	141	-	00.1	E	104	10.5
E3	37	-	51.0	N	141	-	13.0	E	253	8.7
E4	37	-	48.5	N	141	-	02.5	E	112	6.7
E5	37	-	46.0	N	141	-	10.4	E	248	6.6
E6	37	-	43.5	N	141	-	02.7	E	110	7.2
E7	37	-	41.0	N	141	-	11.2	E	247	2.6
E8	37	-	40.0	N	141	-	08.2	E	-	-
									Total	44.2

Block F

Waypoint	Latitude				Longitude				Course (degree)	Distance (n.mile)
F1	37	-	54.0	N	141	-	19.0	E	259	5.3
F2	37	-	53.0	N	141	-	12.4	E	103	8.7
F3	37	-	51.0	N	141	-	23.1	E	256	8.1
F4	37	-	49.0	N	141	-	13.2	E	105	7.9
F5	37	-	47.0	N	141	-	22.8	E	260	11.2
F6	37	-	45.0	N	141	-	08.9	E	101	10.0
F7	37	-	43.0	N	141	-	21.3	E	256	8.2
F8	37	-	41.0	N	141	-	11.2	E	106	3.7
F9	37	-	40.0	N	141	-	15.7	E	-	-
									Total	63.1

Table 2. A summary of the trawl sampling.

Station		St-1	St-2	St-3	St-4	St-5	St-6	St-7	St-8	St-9
Date		10 Apr.	14 Apr.	14 Apr.	14 Apr.	15 Apr.	16Apr.	17 Apr.	22 Apr.	24 Apr.
Time		10:24	14:15	17:28		13:20	14:51	14:37	17:59	14:44
Latitude		36-16N	38-00N	37-54N	37-54N	38-00N	38-12N	38-10N	37-54N	38-13N
Longitude		141-21E	141-02E	141-09E	141-21E	141-23E	141-20E	141-31E	141-16E	141-18E
Temp(°C) by depth	0 m	8.90	8.20	8.50	-	6.20	10.70	6.40	7.20	9.10
	10 m	8.82	8.17	8.48	-	5.96	7.14	6.34	6.47	9.02
	20 m	8.79	8.03	8.34	-	5.65	7.12	5.52	5.90	9.01
	30 m	8.51	7.36	7.58	-	5.29	7.10	6.32	5.57	8.24
	40 m	7.91		6.48	-	5.13	7.67	5.10	5.39	8.01
	50 m				-	5.04		4.74	5.28	
	75 m				-	4.80		4.82	5.20	
	100 m				-	4.67		4.51		
	Bottom (m)	8.00 (37m)	7.93 (28m)	6.45 (31m)	-	4.67 (90m)	6.51 (39m)	4.8 (101m)	5.18 (52m)	7.31 (36m)
Trawl sampling depth (m)		31	21	6		70	20	40	25	20
Major sampled species		Sand lance (juv.)	Sand lance (juv.)	Sand lance (juv.)	Nil	Krill	Sand lance (juv.)	Krill	Nil	Sand lance (juv.)
Catches (kg)		1.9	20.0	1.2	0.0	1.4	12.0	1.0	0.0	12.0



(a)

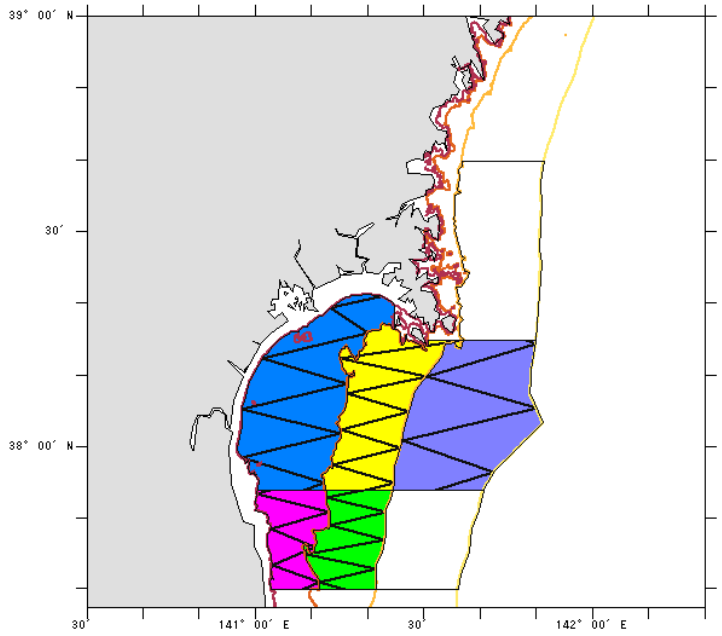


Fig. 1. Survey Blocks (a) and planed tracklines in 2008 (b). Block A and G were not surveyed in 2008.

Appendix 2

Oceanographic conditions in the coastal survey of JARPN II off Sanriku, northeastern Japan, in April 2008

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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 2008 as a part of JARPN II study. Oceanographic observations were conducted with CTD from 10 to 24 April 2008 by *Takuyo-Maru*. According to the CTD data at 29 stations, water masses in the survey area have characteristics of the Cold water (5ºC < temperature < 10ºC at 100 m depth) near the Oyashio Front (5ºC at 100 m depth).

Introduction

The oceanographic condition in 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. 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 onboard *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 2008 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 29 stations from 10 to 24 April 2008 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 2008 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 the Oyashio water, cold low-salinity water (colder than 5 ºC and less than 33.5 psu).

Figure 2 shows a schematic hydrographic map in April 2008. 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 2008 was at 37º20'N on 144ºE line, which was a more southerly position than monthly mean location in April (38º40'N). Tsugaru warm water, which is usually restricted near the coastal area (called as coastal mode) in April, spread eastward to 141 º30'E, and joined with a warm-core ring (around 141 º30'E, 41º30'N). The southern limit of the first Oyashio Intrusion located around 39º10'N, 142ºE, which was a more northerly position than monthly mean location in April (38º30'N), but the cold Oyashio water was cut from the first Oyashio Intrusion to the survey area along the coast of Sanriku. Almost 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) nearby the Oyashio water cut from the first Oyashio Intrusion.

Figure 4 shows temperature and salinity maps at the depth of 50 m and 100 m, observed by *Takuyo-Maru.* Water of 4ºC to 6ºC and 33.4 to 33.6 psu were dominant at the depth of 100 m in Fig. 4. It means that the Cold water and the Oyashio water occupied in the onshore side area and in the offshore side area, respectively.

Figure 5 shows vertical sections of temperature and salinity. Cold low-salinity water (less than 5ºC and 33.3 psu) was dominant at the mid shelf in Fig. 5. Temperature at surface inshore water and offshore water are warmer than 5 ºC in each section.

All of these figures show that all stations are distributed in and around the Oyashio water, cut from the first Oyashio Intrusion.

Acknowledgment

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

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Murakami, M. (1994): On long-term variations in hydrographic conditions in the Tohoku area, *Bull. Tohoku Natl. Fish. Res. Inst*., 56, 47-56 (in Japanese with English abstract).

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

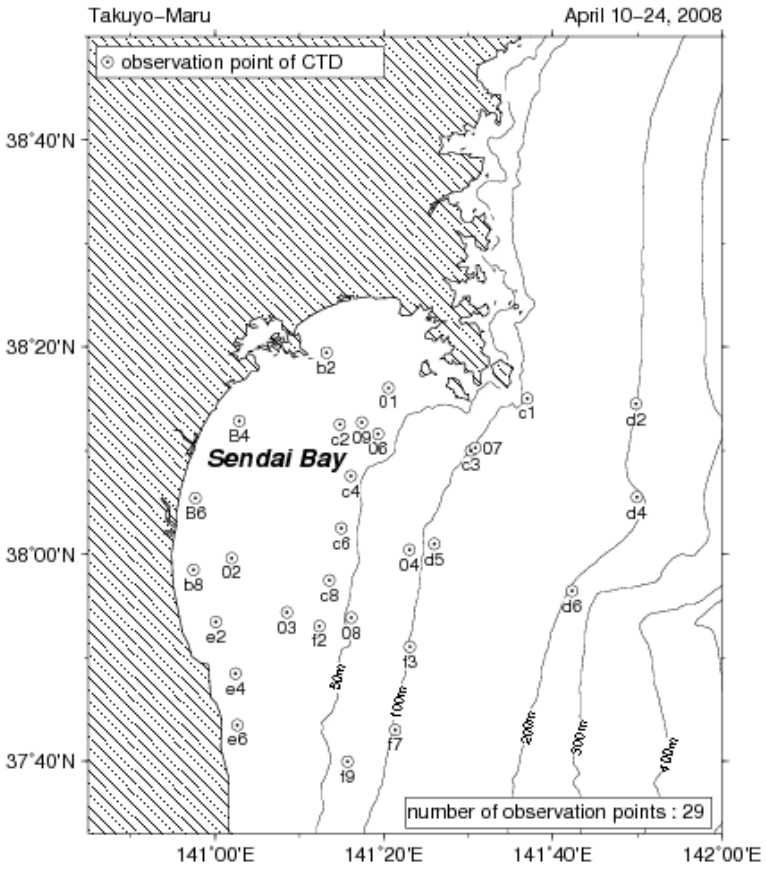

Fig. 1. Station map observed by *Takuyo-Maru* in April 10 to 24, 2008.

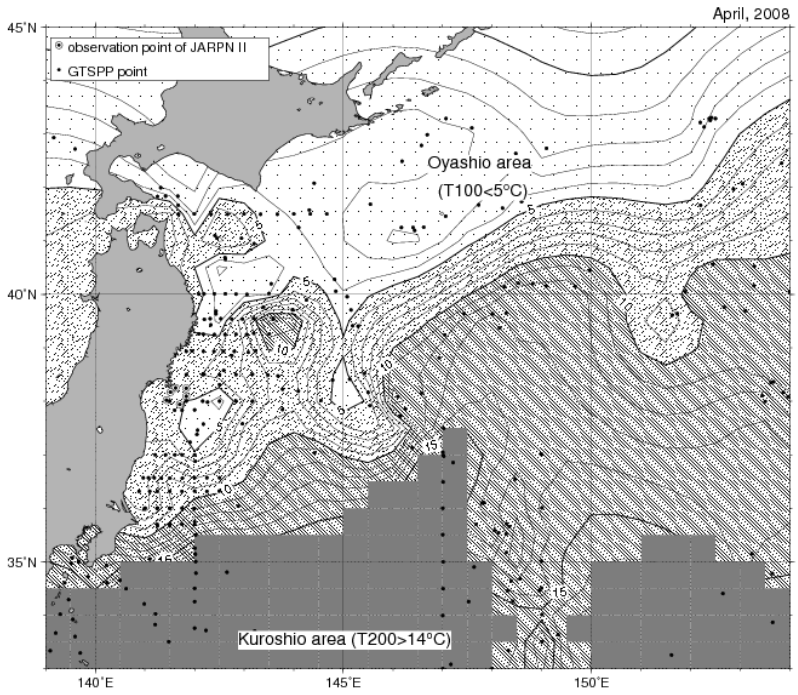

Fig.2. Schematic hydrographic map in Tohoku area, northwestern Pacific, in April 2008 with station map observed by *Takuyo-Maru*.

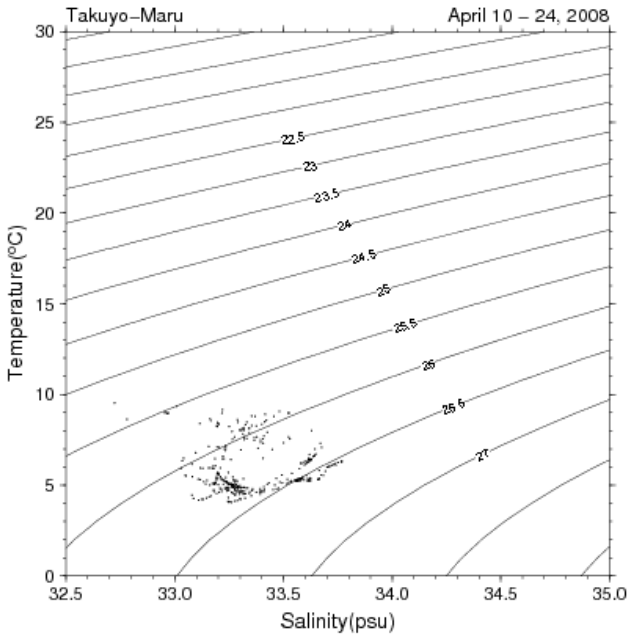

Fig. 3. Temperature-Salinity diagrams using CTD station data observe by *Takuyo-Maru* in April 10 to 24, 2008. Each thin line in this figure denotes a density line of sigma-t.

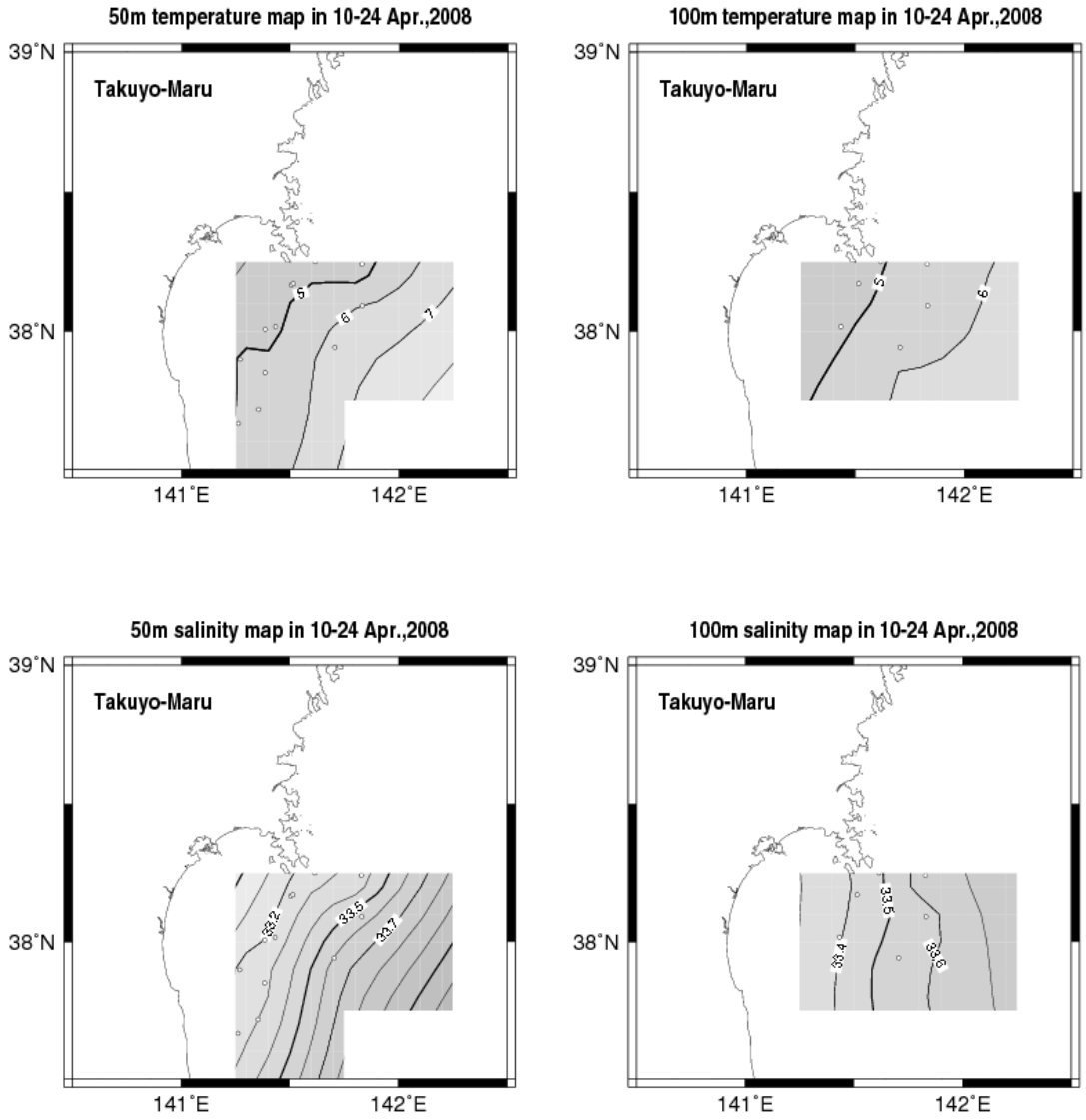

Fig.4. Temperature (upper panels) and salinity (lower panels) maps at 50 m depth (left panels) and 100 m depth (right panels) in the Sanriku coastal area, observed by *Takuyo-Maru* in 10 to 24 April 2008.

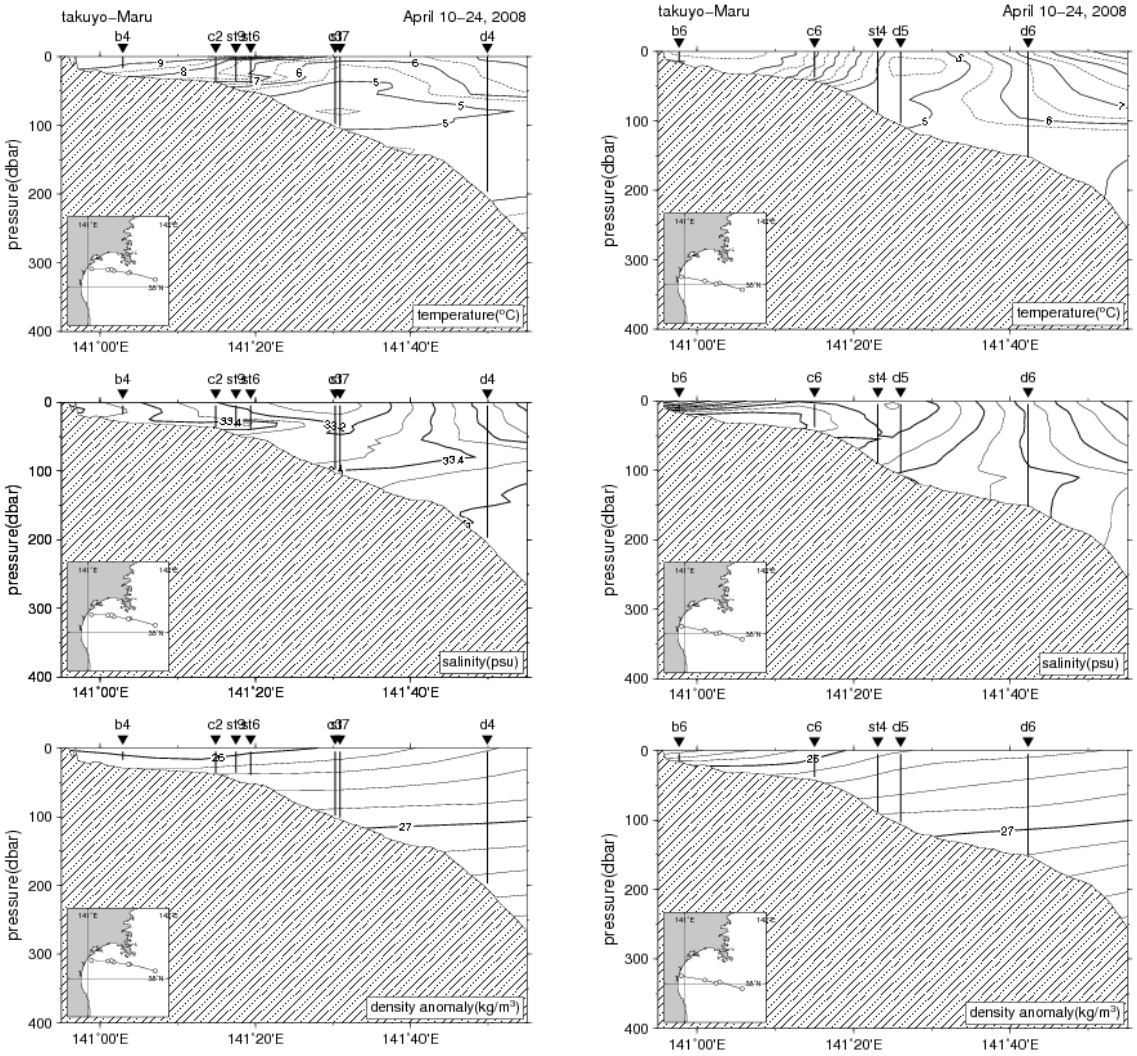

Fig. 5. Temperature (top), salinity (middle) and density anomaly (bottom) sections along selected stations, observed by *Takuyo-Maru* in 10 to 24 April 2008