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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 Kushiro

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ABSTRACT

The fifth survey of the JARPN II coastal component off Kushiro, northeast Japan (northern part of the sub-area 7) was conducted from 10 September to 31 October 2007, using four small-type whaling catcher boats and one echo sounder-trawler and dedicated sighting survey vessel. The sampling was conducted in the coastal waters within the 50 nautical miles from the Kushiro port, and all whales sampled were landed on the land station in the Kushiro port for biological examination. During the survey, a total of 6,827.7 n. miles (637.6 hours) was searched for whale sampling, 98 schools/ 99 individuals of common minke whales were sighted and 50 whales were sampled. Average body length of sampled whales was 6.45m (SD=1.10, n=33) for males and 5.49m (SD=0.81, n=17) for females, respectively. In males, 15 out of 33 animals were sexually mature, while all females (17 animals) collected were sexually immature. Dominant prey species found in the forestomach contents were Japanese anchovy *Engraulis japonicus* (38.0%) and walleye pollock *Theragra chalcogramma* (30.0%). The ratio of the whales fed on walleye Pollock was relatively high in 2007 compared with the results of the previous surveys conducted in 2002 to 2006. Larger and mature whales tend to take Pacific saury *Cololabis saira* and common squid *Todarodes pacificus*, while immature whales mainly took walleye Pollock. These results suggested the possible difference in the food preference between mature and immature individuals in the coastal waters off Kushiro in autumn season, and the variability in the effects for the inshore marine ecosystem and local coastal fisheries through the yearly change in the composition of the whales migrate to the local coastal area.

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

BACKGROUND

The full-scale surveys of the second phase of the Japanese Whale Research Program under Special Permit in the western North Pacific (JARPN II) started in 2002 (Government of Japan, 2002). The objectives of the surveys are: i) feeding ecology and ecosystem studies, involving prey consumption by cetaceans, prey preferences of cetaceans and ecosystem modeling, ii) monitoring environmental pollutants in cetaceans and marine ecosystem, and iii) stock structure of whales (Government of Japan, 2002).

The full-scale JARPN II involves two survey components; 'offshore' which is covered by the *Nisshin Maru* research vessels and 'coastal' which is covered by small-type whaling catcher boats, and the latter one is necessary to cover the temporal and spatial gaps, which can not be covered by the *Nisshin maru* research vessels (Government of Japan, 2002).

Based on the results of the two-year feasibility study of the coastal survey component conducted in 2002 off Kushiro and 2003 off Sanriku district (Kishiro, *et al*., 2003, Yoshida, *et al*., 2004, Government of Japan, 2004a), the coastal component has been revised to be conducted twice a year, with 60 common minke whales being sampled in each of spring off Sanriku and autumn off Kushiro (Government of Japan, 2004b). After the first revised survey carried out off Kushiro in autumn 2004 (Kishiro, *et al*., 2005), the coastal survey off Kushiro was conducted in every years in 2005 and 2006 (Kishiro, *et al*., 2006, Yoshida, *et al*., 2007). This paper presents results of the fifth survey conducted off Kushiro, from 10 September to 31 October in 2007. The 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 cooperate with the Institute of Cetacean Research (ICR) and Tokyo University of Marine Science and Technology.

MATERIALS AND METHODS

Response to the discussion at the IWC/SC meeting

The revised JARPN II research plan was presented at the 56th IWC/SC annual meeting (Government of Japan, 2004b). Results of the surveys off Kushiro conducted in 2004 to 2006 were reported at the following IWC/SC meetings (Kishiro, *et al*., 2005, 2006, Yoshida, *et al*., 2007). Although some discussions were made at those meetings, there remained divided views in the Committee members and no critical or agreed recommendation for the research plan was made (IWC, 2005; 2006; 2007). Thus, the 2007 survey was conducted almost same methodology in the previous surveys. The survey consisted of two research components as follows; 1) coastal whale sampling survey by small-type whaling catcher boats, 2) coastal prey species survey and dedicated sighting survey by one echo sounder-trawler survey vessel with a top barrel. The dedicated sighting survey by other large vessel was not carried out due to the logistic reason.

Research area

The research area was same to the previous surveys (Kishiro, *et al*., 2003, 2005, 2006, Yoshida, *et al*., 2007), i.e. the coastal waters off Kushiro, within the 50 nautical miles form the Kushiro port (Fig. 1). This area is included in the northern part of the sub-area 7 determined by the IWC.

Research vessels and land station

Whale sampling survey

Four small-type whaling catcher boats (*Taisho Maru* No. 28 (hereafter referred as 28T; 47.3GT), *Koei Maru* No.75 (75K; 46.0GT), *Sumitomo Maru* No.31 (31S; 32.0GT) and *Katsu Maru* No.7 (7K; 32.0GT) were used as the whale sampling vessels. The sampling survey was conducted from 10 September to 31 October. All whales sampled were landed on the land station (the JARPN II research station) in the Kushiro port for biological examination of the whales and the by-products.

Prey species survey and large-scale dedicated sighting survey

The *Kaiko Maru* (KK1; 860.3GT) conducted the prey species survey using a quantitative echosounder (SIMRAD ED500), mid-water trawl, and IKMT, in a wider research area off east coast of Hokkaido, from 9 September to 10 October. The survey was conducted along the predetermined zigzag-shaped track lines and also engaged a sighting survey for whales from the top barrel and upper bridge. Oceanographic observation using a CTD was also carried out. Details of the surveys are shown in Appendix 1. Oceanographic conditions revealed from the CTD observations are noted in Appendix 2.

Sampling survey by small-type whaling catcher boat

As same as the former surveys (Kishiro *et al*., 2003, 2005, 2006, Yoshida *et al*., 2007), the research head office was placed in the research station and controlled the sampling vessels during the survey. All catcher boats were engaged as the sampling vessels. To avoid the concentration of sampling location, the research head office arbitrarily determined the searching area and route (direction from the port) for each sampling vessel in every day, based on the information of the whale distribution obtained by the dedicated sighting survey and the past sampling surveys. Weather conditions and information on fishing grounds of prey species were also considered.

In each vessel, a researcher was on board and recorded the cruise tracks, searching time on effort, sea weather conditions and sighting data. Sighting data would be collected for all baleen whales, sperm whales, Baird's beaked whales, killer whales and short-finned pilot whales. The vessel principally continued to cruise and search along the predetermined direction until arrived at 10-30 n. miles from the port, and then freely cruised in the waters within the 50 n. miles radius from the port. Searching was carried out during the day and the vessels returned to the port every night. Sighting was conducted from the top barrel and upper bridge by all the crews and researcher with vessel speed at about 11 knots. All common minke whales sighted were targeted for sampling,

except for the cow-calf pair. When a sighting consisted of more than one animal, first targeted animal was selected following the random sampling digits. Sampling was made by 50 mm whaling cannon. Once the vessel sampled the whale, she returned to the Kushiro port as soon as possible, to land the animal on the research station. At the port, the sampled whale was lift up from the vessel using wire nets and a crane and transported to the station by an 11 tons freight trailer. At that time, body weight of the whale was measured with the truck scale.

Biological research for common minke whales sampled

All sampled whales were biologically examined by researchers at the research station. Research items of the biological studies were summarized in Table 3, with the number of data and samples obtained. These items were related to studies on feeding ecology, stock structure, life historical biology and pollutions.

RESULTS

Effort and sightings by the sampling vessels

The cruise tracks made by the sampling vessels (28T, 75K, 31S and 7K) during the survey are shown in Fig.2. The searching areas covered widely coastal waters within 30 nautical miles form the Kushiro port. Searching distance and time are shown in Table 1. Here, we defined the searching distance and time as that with sighting effort, i.e. the periods of the searching conducted from the top barrel. During the research period, total searching distance and time were 6,827.7 n. miles and 637.6 hours, respectively.

Fig.3 shows distribution of common minke whales sighted by the sampling vessels. Sighting positions widely distributed in inshore areas off Kushiro port to the waters in around 30 n. miles from the port, and relatively concentrated in the southeastern side of the research area on the continental shelf and slope. During the survey, a total of 98 schools/ 99 individuals of common minke whales were sighted, consisting of 85 schools/ 86 individuals of primary sightings and 13 schools/ 13 individuals of secondary sightings (Table 1). These figures probably include some duplicated sightings because sampling vessels searched almost same areas in every day. In addition, Humpback whale (1 school/ 1 individual) and some small cetaceans were sighted during the survey (Table 1).

The temporal change in density index (SPUE: number of schools primary sighted per one hour searching, and DI: number of schools primary sighted per 100 n. miles searching) of common minke whales obtained by the small-type whaling catcher boats are listed in Table 2. In both SPUE and DI, distinct peak was not observed through the research period in 2007, though some figures of October were slightly higher than those of September. During the total research periods, 0.13 schools were primary sighted per one hour searched, and 1.24 schools were primary sighted per 100 n. miles

searched. These figures were higher than that recorded in last year 2006 survey (SPUE=0.08, DI=0.76, Yoshida *et al*., 2007).

Sampling of common minke whales

A total of 50 common minke whales were sampled. In the sampling process, there were no struck and lost animals. Fig.3 showed sighting positions of sampled whales. Distribution of these whales almost covered all of the areas where the sightings were made during the research period.

Prey species survey and large-scale dedicated sighting survey

The prey species survey and dedicated sighting survey were conducted by one research vessel (KK1) to investigate the distribution and abundance of the prey species and whales in the wider areas from west side of Cape Erimo (142º30'E) to east side of Cape Nosappu (about 146º30'E) and north of 41º00'N. Japanese anchovy was unevenly distributed and slightly concentrated in the west side of the research area but density in whole area was low. Small amount of Pacific saury was found in the southeastern side of the area around 30 to 40 n. miles off Kushiro. Walleye pollock was found along the 100 to 150m isobath on the continental shelf and slope. A total of 7 schools/ 7 individuals of common minke whales were primary sighted during the survey with a 958.4 n.miles searching effort. Detailed results of those surveys were described in Appendix 1.

Sex ratio, body length and weight of sampled whales

The 50 sampled whales were consisted of 33 males and 17 females (sex ratio of males was 0.66). Average body length of the whales was 6.45m (max=7.83, min=4.31, SD=1.10) for males and 5.49m (max=7.43, min=4.23, SD=0.81) for females, respectively (Table 4). Average body weight was 3.54 tons (max=6.08, min=1.02, SD=1.66) for males and 1.93 tons (max=3.92, min=0.84, SD=0.78) for females, respectively (Table 5). Distinct temporal change in average body length and weight was not observed. Figures in males were lowest in late October and those in females were lowest in late September. Large animals with body length of 8m or more were not collected through the total research period. Composition of sex and sexual maturity of common minke whales is listed in Table 6. Maturity of male was tentatively determined by the histological observation of testis. Female had at least one corpus luteum or albicans in their ovaries was determined as mature. In males, 15 of 33 individuals were sexually mature (45.7%). This figure was lower than that of the previous surveys, e.g. 52.0% in 2006 and 66.7% in 2005. All females sampled were immature (n=17), and sexually mature females was not observed.

Prey species of common minke whale found in the stomach contents

Stomach contents of all collected animals were examined except for one, which was broken by harpoon (Table 7). 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 four chamber in both cases

of including and excluding liquid. Then, a sub-sample of stomach contents was collected and frozen for the later laboratory work. Five prey species, Japanese anchovy *Engraulis japonicus,* Walleye pollock *Theragra chalcogramma,* Pacific saury *Cololabis saira,* Japanese common squid *Todarodes pacificus,* and Krill were found in the forestomach contents. Among them, Japanese anchovy was the most dominant prey species, and found throughout the survey. Ratio of the whales mainly fed on Japanese anchovy was 38.0% or 19 out of 50 whales. Next dominant prey species was Walleye pollock. The frequency of occurrence for this species was especially high in late September to early October, and total ratio of the whales mainly fed on Walleye pollock throughout the survey (30.0% or 15 out of 50 whales) was higher than those recorded in the previous surveys off Kushiro. The forestomach contents weights ranged form 2.68Kg (Krill) to 123.4Kg (Pacific saury) and average weight was 28.1Kg.

By-products of the whales

After biological examination, all whales sampled were processed according to the International Convention for Regulation of Whaling, Article VIII. A total weight production including meat and blubber was 83.5 tons.

Fishing grounds of coastal fisheries during the 2007 survey period

Fig.4 shows the distribution of fishing grounds of the local coastal fisheries for Pacific saury (dip net fisheries), Japanese anchovy (purse seine fisheries) and Japanese common squid (jigging fisheries) around the coastal waters off northern Japan including Kushiro during the 2007 survey period (Japan Fisheries Information Service Center, 2007). In September, many fishing boats for Pacific saury and Japanese common squid operated in the research area off Kushiro, but catch of Pacific saury in this area was decreased just after the whale sampling survey started, and fishing grounds for Pacific saury was moved to slightly offshore and outside of the research area. Fishing grounds for Japanese common squid was disappeared in October. Fishing grounds for Japanese anchovy was distributed along the coastal waters off Sanriku district (out side of the research area) during the whole survey period and purse seine fisheries for the anchovy was not operated in the coastal waters off Kushiro. The distributions of these fishing grounds implied that the amount of preys such as Pacific saury and Japanese anchovy for common minke whales was not abundant in the whale sampling area during the 2007 research periods, especially in October.

DISCUSSION

The present survey was the fifth survey of the JARPN II coastal component in the autumn season off Kushiro. There was no practical problem in conducting the surveys as same as the previous surveys. However, bad weather conditions such as typhoons, low atmospheric pressures and thick fog often disturbed research activities. Of total 52 day survey period from 10 September to 31 October, sampling vessels could conduct the research for 35 days or 67.5% of the time. This was almost same

in the last year survey (70.6% in 2006). In the last year survey, unusually high sea surface temperature was observed and migration of common minke whales into the research area was thought to be extremely low (Yoshida *et al*., 2007). In 2007, apparent warm water mass was not observed in the research area, and the sea surface temperature ranged from 13.2℃ to 19.8℃ (average: 16.0℃) in September and 11.4℃ to 16.0℃ (Average: 13.7℃) in October. These figures were lower than that of 2006 and the density index of common minke whales recorded by the sampling vessels in 2007 was higher than that of the 2006 survey. These results suggested that the migration of common minke whales in 2007 was more abundant than 2006 and the bad whether condition to disturb research activities was thought to be a major reason which did not reach a planed sample size in the 2007 survey.

Frequency distribution of body length of common minke whales collected in 2007 was similar to those in 2006, but large animals with body length of 8m or more were not observed, and the ratio of sexually mature individuals was lower than that of the previous surveys, and furthermore, mature female was not collected. These results suggested that the migration of main groups of common minke whales including mature females into the research area was scarce in 2007, as supposed in 2004 and 2005 (Kishiro, *et al*. 2005; 2006). This might be related to the low density of prey species such as Pacific saury and Japanese anchovy suggested from the results of the prey species survey (Appendix 1) and the fishing grounds for these prey species (Fig. 4).

Composition of prey species found in the stomach contents in the present survey was apparently different and the ratio of the whales fed on walleye Pollock was relatively high in 2007 compared with the results of the previous surveys conducted in 2002 to 2006 (Fig.6). Larger and mature whales tend to take Pacific saury and common squid, while immature whales mainly took walleye Pollock (Fig.7). These results suggested the possible difference in the food preference between mature and immature individuals in the coastal waters off Kushiro in autumn season, although the stomach contents might be also related to the distribution of prey species and catch position of each whale (Fig.8), and further analysis is needed.

It has been six years since the coastal survey off Kushiro was started in 2002 as a part of the full-scale JARPN II surveys. The analyses of the samples and data obtained through the surveys are on going with respect to the various aspects such as the feeding ecology, stock structure, pollution studies, and ecosystem modeling. These progress and results will be presented at the future IWC review meeting for the JARPN II.

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Table 1. Searching days, hours, distances, number of sightings and catch of common minke whales made by the sampling survey off Kushiro in 2007.

Period	Days	Hours	Distances (n.miles)	Species[*3]	No. of sightings						No. of Catch	DI[*1]	SPUE[*2]
					Primary		Secondary		Total				
					Sch.	Ind.	Sch.	Ind.	Sch.	Ind.			
10 Sept. - 15 Sept.	5	114.8	1,232.7	Common minke whale	16	16	5	5	21	21	7	1.30	0.14
				Like minke whale	7	7	1	1	8	8			
				Unidentified cetaceans	1	1	-	-	1	1			
16 Sept. - 30 Sept.	10	190.6	2,050.4	Common minke whale	21	21	3	3	24	24	14	1.02	0.11
				Like minke whale	10	10	-	-	10	10			
				Humpback whale	1	1	-	-	1	1			
				Unidentified cetaceans	3	3	1	1	4	4			
1 Oct. - 15Oct.	12	221.6	2,372.9	Common minke whale	27	28	2	2	29	30	16	1.14	0.12
				Like minke whale	10	10	1	1	11	11			
				Unidentified cetaceans	3	3	-	-	3	3			
16 Oct. - 31 Oct.	8	110.6	1,171.7	Common minke whale	21	21	3	3	24	24	13	1.79	0.19
				Like minke whale	5	5	1	1	6	6			
				Unidentified cetaceans	2	2	-	-	2	2			
Total	35	637.6	6,827.7	Common minke whale	85	86	13	13	98	99	50	1.24	0.13
				Like minke whale	32	32	3	3	35	35			
				Humpback whale	1	1	-	-	1	1			
				Unidentified cetaceans	9	9	1	1	10	10			

*1: No. of primary schools sighted per 100 n.miles searching.
*2: No. of primary schools sighted per 1 hour searching.
*3: Sightings of small cetaceans are not listed.

Table 2. Seasonal change in density index of common minke whales in the 2007 coastal survey off Kushiro, in the JARPN II.

Period	Primary sightings Sch.	Primary sightings Ind.	Searching Hour	Distances (n.miles)	DI*1	SPUE*2
10 Sept. - 14 Sept.	12	12	95.5	1034.3	1.16	0.13
15 Sept. - 19 Sept.	11	11	83.6	888.3	1.24	0.13
20 Sept. - 24 Sept.	8	8	77.0	838.9	0.95	0.10
25 Sept. - 29 Sept.	2	2	23.6	251.8	0.79	0.08
30 Sept. - 4 Oct.	20	20	138.9	1472.5	1.36	0.14
5 Oct. - 9 Oct.	0	0	9.5	103.7	0.00	0.00
10 Oct. - 14 Oct.	7	8	64.8	700.5	1.00	0.11
15 Oct. - 19 Oct.	16	16	81.5	860.3	1.86	0.20
20 Oct. - 24 Oct.	2	2	15.8	164.7	1.21	0.13
25 Oct. - 29 Oct.	3	3	22.7	241.1	1.24	0.13
30 Oct. - 31 Oct.	4	4	24.7	271.8	1.47	0.16
Total	85	86	637.6	6827.7	1.24	0.13

*1: No. of primary schools sighted per 100 n.miles searching

*2: No. of primary schools sighted per 1 hour searching

Table 3. Summary of biological data and samples collected during the 2007 coastal survey off Kushiro, in the JARPN II.

Samples and data	Number of whales Male	Female	Total
Body length and sex	33	17	50
External body proportion	33	17	50
Photographic record and external character	33	17	50
Diatom film record	33	17	50
Body scar record	33	17	50
Measurements of blubber thickness (five points)	33	17	50
Detailed measurements of blubber thickness (eleven points)	4	1	5
Body weight	33	17	50
Body weight by parts	4	1	5
Skin tissues for DNA study	33	17	50
Muscle, liver, kidney and blubber tissues for heavy metal analysis	33	17	50
Muscle, liver, kidney and blubber tissues for organic chlorine analysis	33	17	50
Muscle and blubber tissues for byproduct analysis	33	17	50
Muscle, liver, spleen, heart and blubber tissues for chemical analysis	33	17	50
Urine for chemical analysis	22	9	31
Mammary grand; lactation status, measurement and histological sample	-	17	17
Uterine horn; measurement and endometrium sample	-	17	17
Collection of ovary	-	17	17
Testis and epididymis; weight and histological sample	33	-	33
Stomach content, conventional record	33	17	50
Volume and weight of stomach content in each compartment	33	17	50
Stomach contents for feeding study	32	15	47
Stomach contents for multipurpose study	3	1	4
Record of external parasites	33	17	50
Earplug for age determination	32	17	49
Tympanic bulla for age determination	20	16	36
Largest baleen plate for morphologic study and age determination	33	17	50
Baleen plate measurements (length and breadth)	33	17	50
Photographic record of baleen plate series	33	17	50
Length of each baleen plate series	33	17	50
Crystalline lens in eyeball for age determination	33	17	50
Blood serum for chemical analysis	32	16	48
Vertebral epiphyses sample	33	17	50
Number of ribs	33	17	50
Brain weight	4	1	5
Skull measurement (length and breadth)	33	17	50

Table 4. Body length (m) of common minke whales sampled by the 2007 coastal survey off Kushiro, in the JARPN II.

	Male					Female				
Period	Mean	S.D.	Min.	Max.	n	Mean	S.D.	Min.	Max.	n
10 Sept.- 15 Sept.	6.53	1.03	5.45	7.50	3	6.04	1.09	4.88	7.43	4
16 Sept. - 30 Sept.	6.59	1.35	4.41	7.83	9	4.90	0.56	4.23	5.74	5
1 Oct. -15 Oct.	6.58	1.18	4.31	7.69	11	5.25	0.55	4.77	6.20	5
16 Oct. -31 Oct.	6.14	0.86	4.80	7.28	10	6.14	0.24	5.90	6.38	3
Total	6.45	1.10	4.31	7.83	33	5.49	0.81	4.23	7.43	17

Table 5. Body weight (t) of common minke whales sampled by the 2007 coastal survey off Kushiro, in the JARPN II.

	Male					Female				
Period	Mean	S.D.	Min.	Max.	n	Mean	S.D.	Min.	Max.	n
10 Sept.- 15 Sept.	3.73	2.02	2.12	6.00	3	2.45	1.05	1.52	3.92	4
16 Sept. - 30 Sept.	3.71	1.76	1.20	5.80	9	1.40	0.44	0.84	2.06	5
1 Oct. -15 Oct.	3.66	1.84	1.02	6.00	11	1.66	0.58	1.26	2.68	5
16 Oct. -31 Oct.	3.19	1.48	1.44	6.08	10	2.59	0.24	2.32	2.74	3
Total	3.54	1.66	1.02	6.08	33	1.93	0.78	0.84	3.92	17

Table 6. Composition of sex and sexual maturity of common minke whales sampled by the 2007 coastal survey off Kushiro, in the JARPN II.

	Male				Female							
Period	Imm.	Mat.	Total	Marutity (%)	Imm.	Rest.	Lact.	Preg.	Total	Pregnancy (%)*1	Maturity(%)	Sex ratio (%males)
10 Sept.-15 Sept.	2	1	3	33.3	4	0	0	0	4	-	0.0	42.9
16 Sept.- 30 Sept.	3	6	9	66.7	5	0	0	0	5	-	0.0	64.3
1 Oct.- 15 Oct.	5	6	11	54.5	5	0	0	0	5	-	0.0	68.8
16 Oct.- 31 Oct.	8	2	10	20.0	3	0	0	0	3	-	0.0	76.9
Total	18	15	33	45.5	17	0	0	0	17	-	0.0	66.0

*1: Apparent pregnancy rate

Table 7. Number of common minke whales by major prey species found in their forestomach contents sampled by the 2007 coastal survey off Kushiro, in the JARPN II.

	No. of whales (%)						
Period	Japanese anchovy	Pacific saury	Walleye pollock	Krill	Common Squid	Unknown*	Total
10 Sept.-15 Sept.	3 (42.9)	1 (14.3)	1 (14.3)	2 (28.6)	- (0.0)	- (0.0)	7
16 Sept.- 30 Sept.	6 (42.9)	1 (7.1)	6 (42.9)	- (0.0)	1 (7.1)	- (0.0)	14
1 Oct.- 15 Oct.	4 (25.0)	3 (18.8)	8 (50.0)	1 (6.3)	- (0.0)	- (0.0)	16
16 Oct.- 31 Oct.	6 (46.2)	3 (23.1)	- (0.0)	3 (23.1)	- (0.0)	1 (7.7)	13
Total	19 (38.0)	8 (16.0)	15 (30.0)	6 (12.0)	1 (2.0)	1 (2.0)	50

*Stomach was broken by harpoon

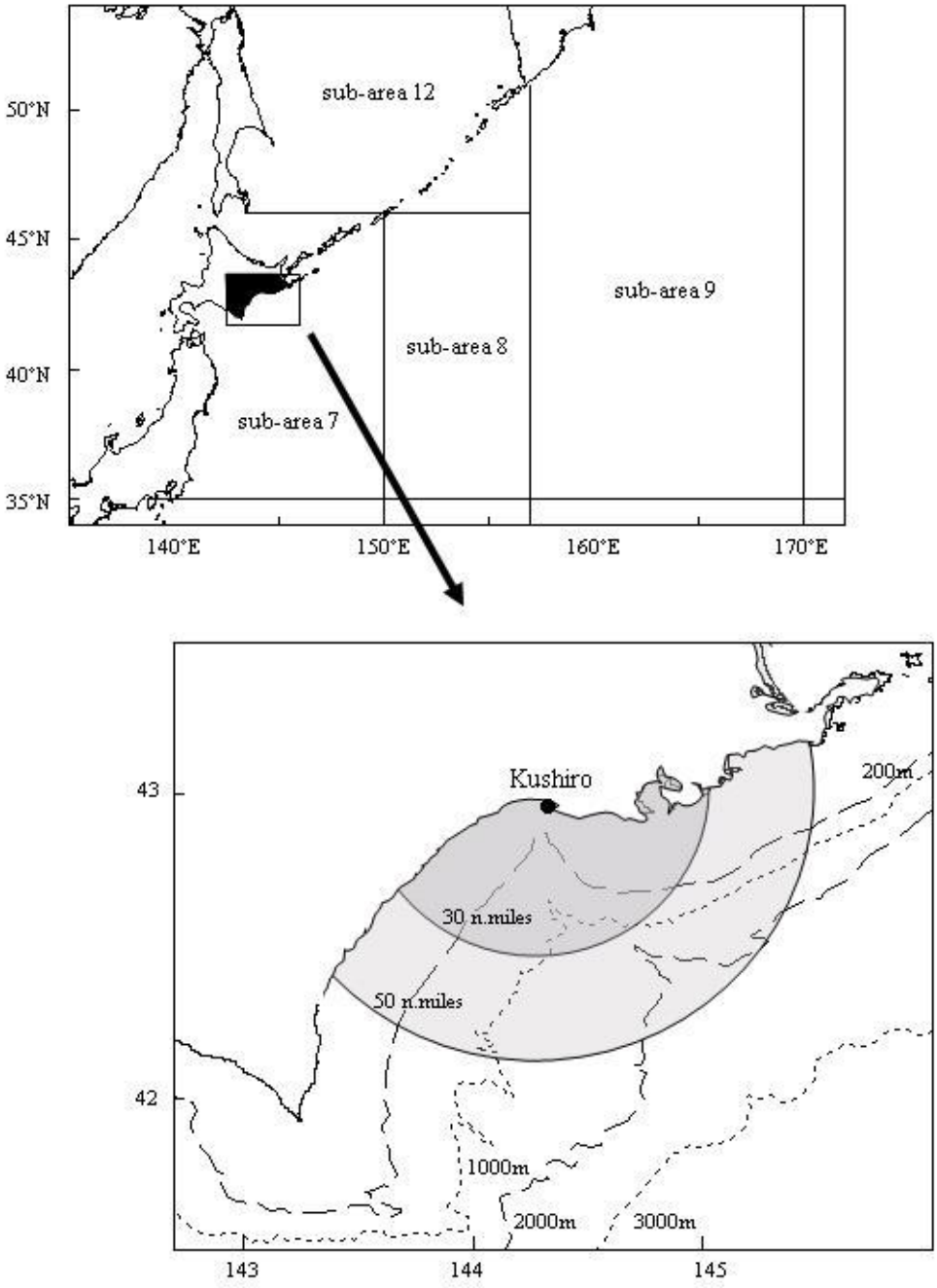

Fig.1. The IWC sub-area for western North Pacific minke whales (upper) and
Research area of the 2007 coastal survey off Kushiro, in the JARPN Ⅱ (lower).

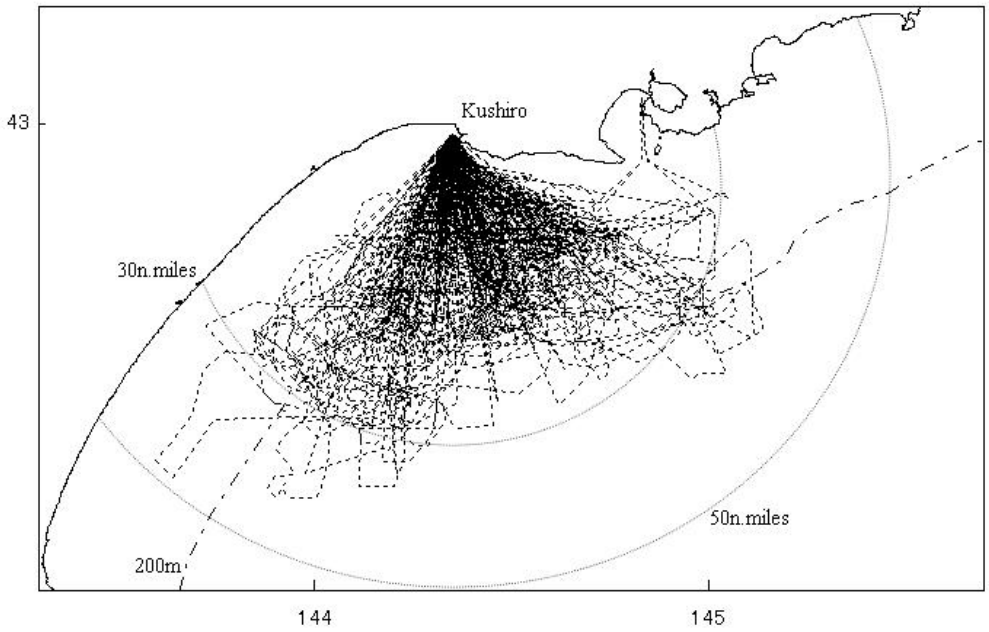

Fig.2. Cruise tracks of the whale sampling survey in the 2007 coastal survey off Kushiro.

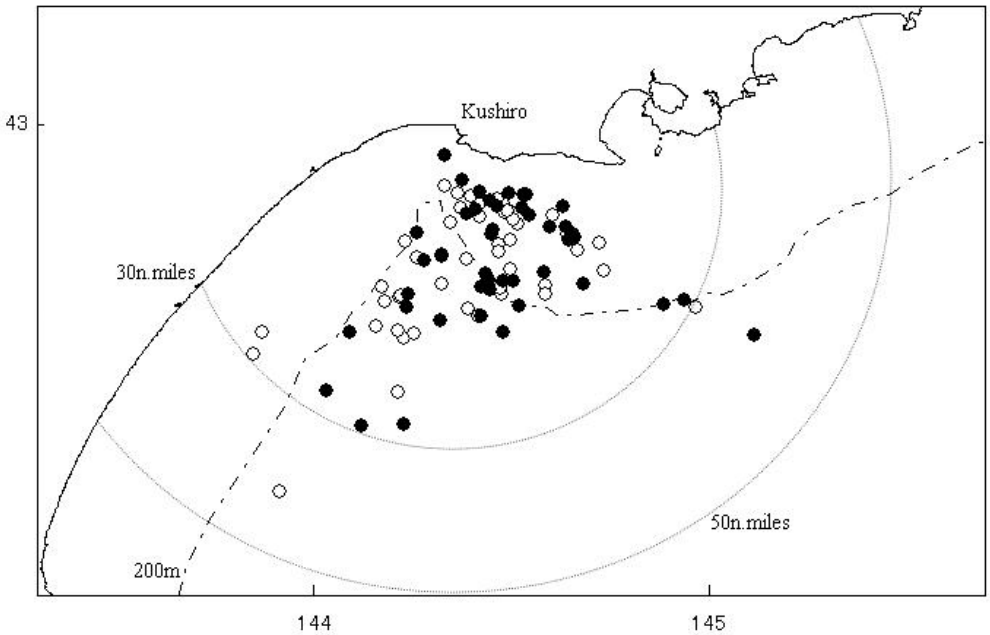

Fig.3. Sighting positions of common minke whales made by the whale sampling survey in the 2007 coastal survey off Kushiro. Closed circle indicates sighting position of sampled whale.

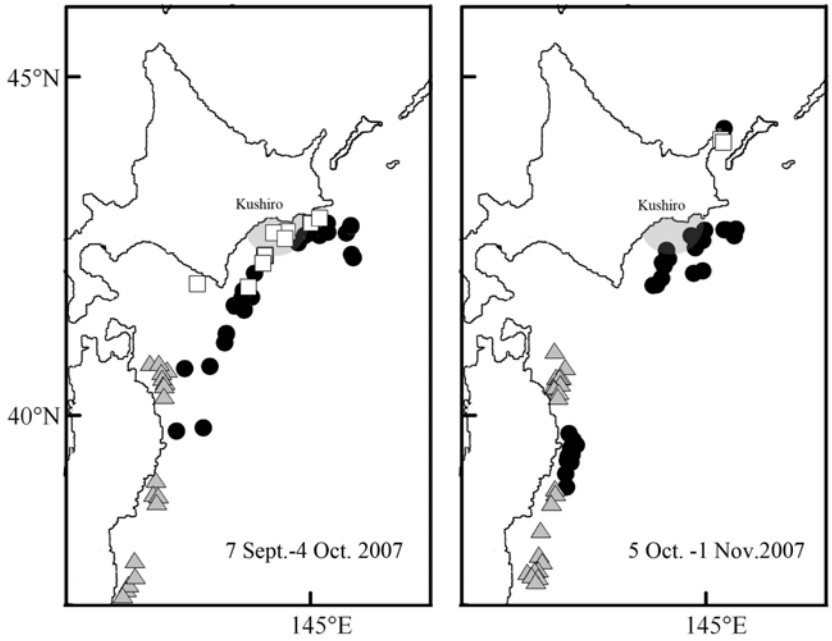

Fig.4. Fishing grounds of the coastal fisheries for prey species in 2007 autumn season. Closed circle: Pacific saury; Open square: common squid; Gray triangle: Japanese anchovy; Shaded area: research area for the whale sampling.

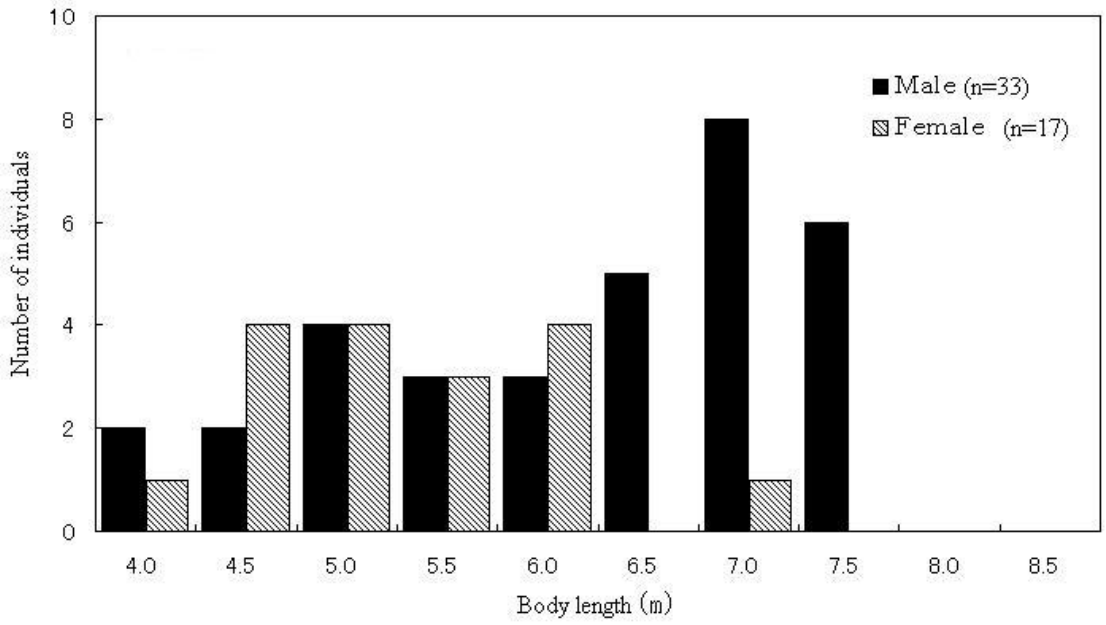

Fig.5. Body length frequency of common minke whales sampled by the 2007 coastal survey off Kushiro.

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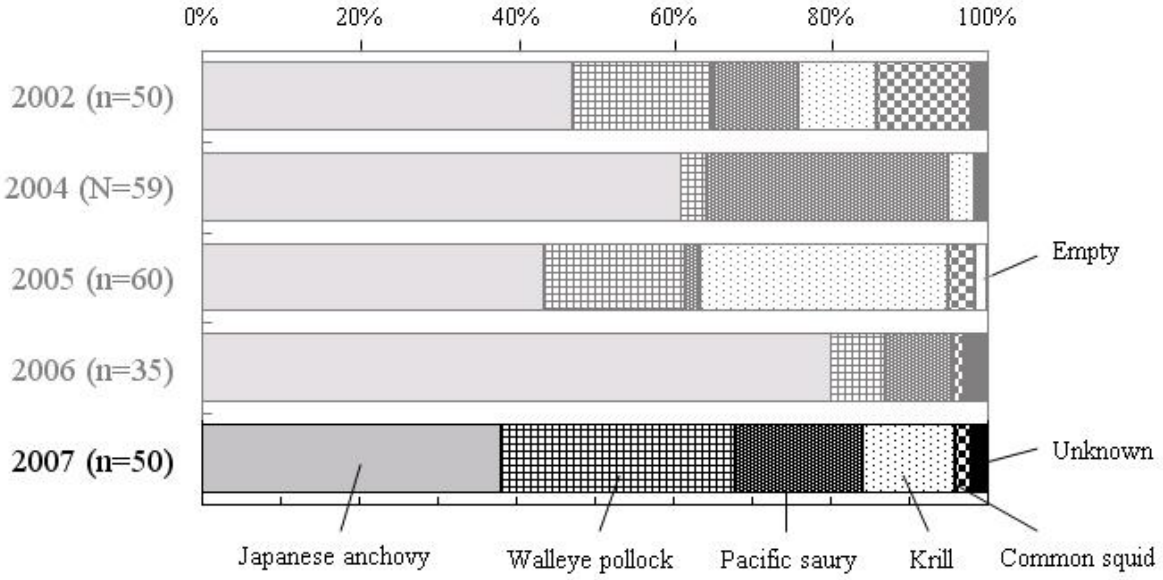

Fig.6. Composition of common minke whales with major prey species found in the forestomach contents in the coastal survey off Kushiro from 2002 to 2007.

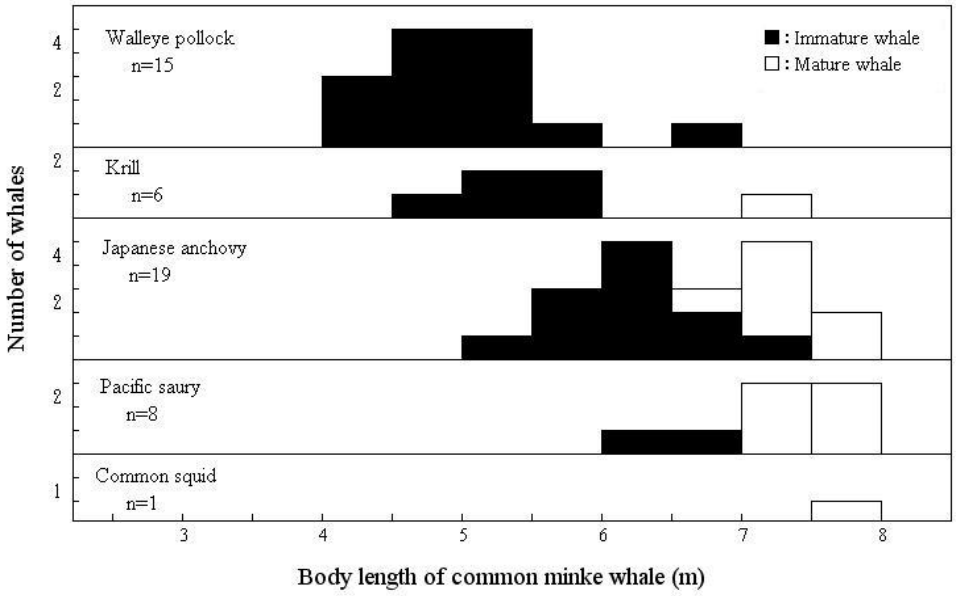

Fig.7. Sexual maturity and body length frequency of common minke whales by their major prey species found in the forestomach contents in the 2007 coastal survey off Kushiro.

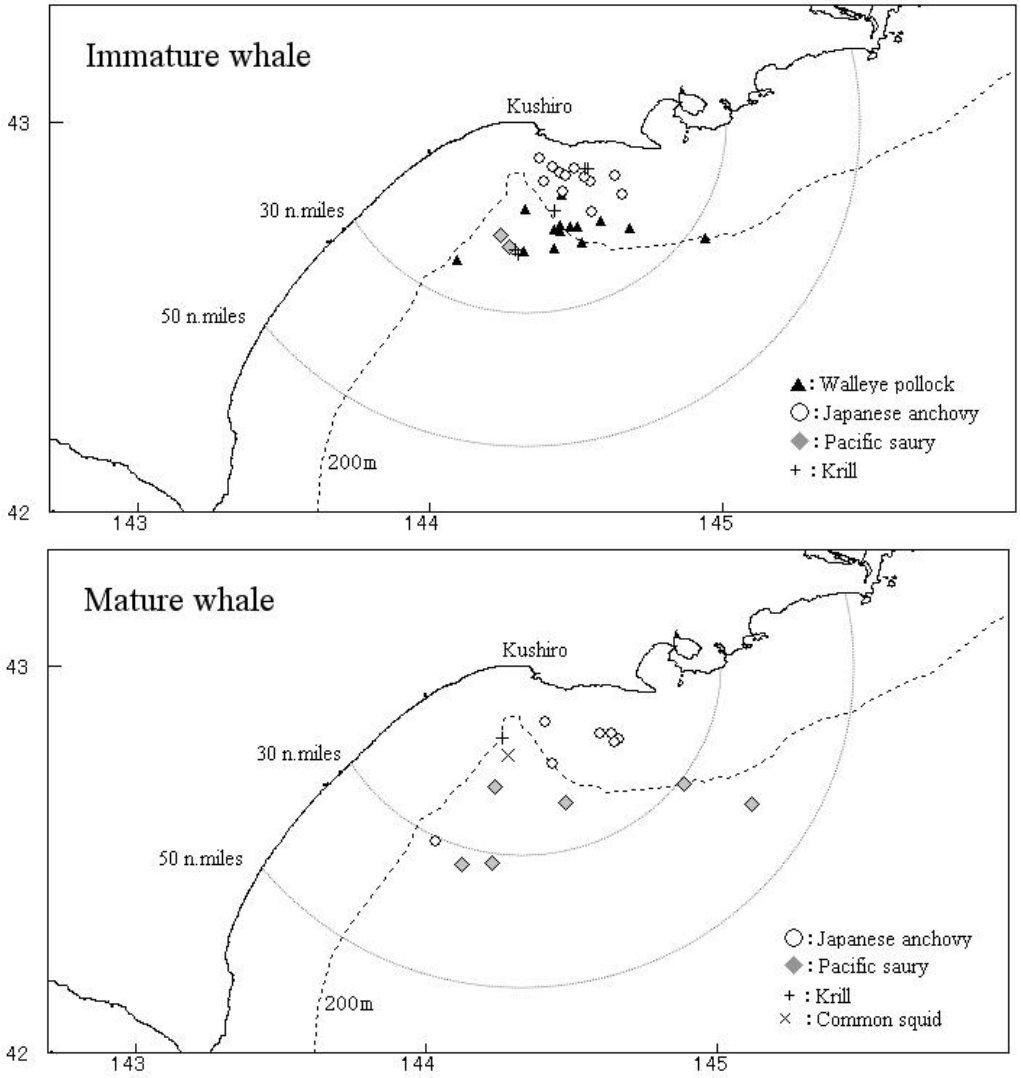

Fig.8. Sighting positions of collected common minke whales by their sexual maturity and major prey species found in the forestomach contents in the 2007 coastal survey off Kushiro.

Appendix 1

Coastal prey species and whale sighting surveys of JARPN II off Kushiro 2007

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ABSTRACT

Prey species and sighting surveys for cetaceans were conducted to examine prey environment, prey preference, and distribution pattern of common minke whale *Balaenoptera acutorostrata* in cooperation with the sampling survey of the whale by small-type catcher boats off Kushiro, eastern Hokkaido, in September and October 2007 as a part of coastal component of JARPN II. The distribution, abundance, and size composition of the prey were investigated with the quantitative echosounder, midwater trawl, and Isaacs-Kidd midwater trawl by the research vessel Kaiko-Maru. According to the sampling data of predetermined trawl, Japanese anchovy *Engraulis japonicus* was the most abundant small pelagic fish, followed by Japanese common mackerel *Scomber japonicus*. However, distributions of Japanese sardine were almost restricted to the coastal area within 10 to 20 nautical miles from the coast where sea surface temperature (SST) was > 15˚C, and most of Japanese common mackerel were distributed in the offshore region out of 50 nautical miles from Kushiro where SST was > 16˚C. Other small pelagic fish such as Japanese sardine *Sardinops melanostictus* and Pacific saury *Cololabis saira* were rarely collected. Catches of Japanese common squid *Torarodes pacificus* were also extremely low, which coincides with the information of the fisheries in the eastern Hokkaido in autumn. During sighting survey, a total of 958.4 nautical miles were searched and we found 7 individuals from 7 schools of common minke whale as primary sightings, which were mainly distributed around first branch of the Oyashio of between 20 and 40 nautical miles from the coast. This suggests that prey environment of the whale was poor in relation to the epipelagic small fish and squid prey. Other potential prey species, walleye Pollock *Theragra chalcogramma* were distributed in the 100 to 150 m depth in the slope water area, and Pacific krill *Euphausia pacificus* were distributed mainly in the 150 to 200 m depth in the offshore region.

KEY WORDS: PREY SPECIES SURVEY, SIGHTING SURVEY, KUSHIRO, AUTUMN, 2007

INTRODUCTION

The objective of JARPN II is to contribute to the conservation and sustainable use of marine living resources including marine mammals in the western North Pacific, especially within Japan's EEZ (Government of Japan, 2002). The priority of this study is put on to accumulate information of prey preference and prey consumption of cetaceans to construct ecosystem models. As it is difficult to cover the coastal area by the Nisshin-Maru, JARPN II has a new coastal component, i.e. the sampling survey for common minke whale by small-type whaling catcher boats. In September and October 2007, the cooperative whale/prey surveys were conducted in the coastal region off Kushiro, eastern Hokkaido, as in 2002, 2004, 2005, and 2006. During this survey, sighting survey was also conducted to estimate abundance of minke and other baleen whales in this study area, which is important to estimate feeding impact of these whales on prey species including commercially important fish and squids, such as Pacific saury *Cololabis saira* and Japanese common squid *Todarodes pacificus*. This document presents the preliminary results of the prey species survey and sighting survey for cetaceans. The results of oceanographic condition in the studied area were depicted in Appendix 2.

MATERIALS AND METHODS

The prey and sighting surveys covered wide area off the eastern Hokkaido, from 142º30'E to 147º00'E, and north of 41ºN except for Russian EEZ to elucidate the distribution and abundance of minke whale and its main prey species (Fig. 1). In this study area, the sampling survey of minke whale was conducted in the coastal waters within the 30 nautical miles (maximum 50 nautical miles) from Kushiro. As many fishing gears were set near the shore, the waters shallower than 50 m were excluded in principle. The survey area was divided into coastal and offshore parts. The coastal part was further divided into east, central, west and off-Hidaka parts. Zigzag track lines were set to cover each part. The waypoints of planned track lines are shown in Table 1.

All survey was conducted in the daylight period from one hour after sunrise to one hour before sunset (generally from 06:00 to 17:00 in local time) from September 9 to October 10, 2007. The distribution and abundance of the prey species were investigated with the quantitative echosounder (SIMRAD EK500), midwater trawl and Isaacs-Kidd midwater trawl (IKMT) by the stern trawler-type research vessel, Kaiko-Maru (860.25 GT) by moving at about 10.5 knots on the track lines. Acoustic data were acquired with Echoview Ver.3 (Sonar Data Co., Ltd.). Calibrations were carried out off Shiranuka near Kushiro in October 7 using the copper sphere technique. The midwater trawl net had a mouth opening of about 30 x 30 m with a 17.5 mm liner cod end. The sampling depth and the height of the mouth of the net were monitored with SIMRAD PI32 net monitor system and the small-type temperature and depth recorders (TDR). Towing speed was 3-5 knots for the trawl and 2 knots for IKMT.

A total of 26 times midwater trawl survey was conducted. Of these, samplings at

predetermined stations were conducted 25 times to examine the distribution and abundance of squids and neustonic organisms like Pacific saury that are difficult to detect with the echosounder. Target trawl survey was conducted one time to identify the species and size compositions of biological backscatterings detected by the echosounder. At each predetermined station, trawl net was towed at 0-100 m or 0-30 m. All samples were identified to the lowest taxonomic level possible and wet body weight of each species was measured aboard the ship. For the major species, body length of 100 individuals was measured. IKMT samplings were conducted two times to identify the species and size compositions of backscatterings of the krill near Kushiro where minke whale was distributed. Samples were fixed in 10% buffered formalin seawater. A CTD cast was made down to 500 m or near the bottom where depth was less than 500 m at each sampling station to measure temperature and salinity profile in the study area.

Sighting survey was conducted along with prey species survey in passing mode, but abeam closing survey was also conducted within 2 nautical miles perpendicular to track line in case that the species of baleen whale could not identified in passing mode. During the survey, primary observers were allocated to the top barrel (3 observers) and the upper bridge (2 observers). In addition, we also conducted special sighting survey on 7 October under the direction of the head of sampling survey within 30 nautical miles off Kushiro.

RESULTS

Prey species survey: The results of trawling operations and the catches by species are shown in Table 2. The detail data of oceanographic conditions are described in Appendix 2 in this report. The preliminary results on distribution and abundance of main prey species of minke whale based on the data of predetermined trawl are depicted in Fig. 2. Among the small epipelagic fish and squids, Japanese anchovy *Engraulis japonicus* (10-15 cm in scale length) was the most abundant and mainly captured in the continental shelf region west of Kushiro within 10 to 20 nautical miles from the coast where sea surface water temperature (SST) was > 15˚C (Fig. 2a). Juvenile Japanese common mackerel *Scomber japonicus* (19-26 cm in fork length, FL) was secondly abundant and was mainly distributed in the offshore area of 16-19˚C SST (Fig. 2b). Japanese sardine *Sardinops melanostictus* (11-17 cm in scale length), Pacific saury *Cololabis saira* (23-34 cm in knob length), and Japanese common squid *Todarodes pacificus* (8-24 cm in dorsal mantle length) were also collected in the coastal area east of Kushiro (> 15˚C SST), in the Oyashio first branch area where was located 30 to 40 nautical miles off Kushiro (< 14˚C SST), and from inshore to off shore area (13-20˚C SST), but abundance of these species were low (Fig 2c-e). In this year, it was remarkable that middle and large sized nekton, Pacific pomfret *Brama japonica* (28-34 cm and 40-48 cm FL) and Chum salmon *Onchoryncus keta* (56-71 cm FL) were frequently collected in or close to the Oyashio first branch area (Fig. 2f, g).

The acoustic data observed at sea suggested that walleye Pollock *Theragra chalcogramma*

were distributed in the 100 to 150 m depth in the slope water area, and krill were distributed mainly in the 150 to 200 m depth in the offshore area. Furthermore, we also found that krill was distributed bimodally, i.e. part of the population was distributed in the 50 m layer and another part in the 100 to 150 m layer, in or close to the Oyashio first branch off eastern Kushiro, where one individual of minke whale was distributed. We collected these krill samples by IKMT from these two depths (see Table 2) and its species and size compositions are analysing now.

Sighting survey: A total of 958.4 nautical miles was searched except for special sighting survey, which search distance was 62.8 nautical miles. A total of 2962 animals of 402 schools (4 baleen whale species and 7 toothed whale species) were found as primary sighting. Among large whale species, 7 individuals from 7 schools of common minke whale, 1 individual of Bryde's whale, 5 individuals from 4 schools of sei whale, 1 individual of fin whale, and 6 individuals from 6 schools of sperm whale were found as primary sighting (Table 3). One animal of sperm whale were also found as secondly sighting. Of these, minke whale was mainly distributed around first branch of the Oyashio, between 20 and 40 nautical miles from the coast (Fig. 3). Bryde's and sei whales occurred in the south eastern part of the study area where was strongly affected by subtropical waters and its SST was 20 to 21˚C (Fig. 3). All sperm whales were found offshore region out of 50 nautical miles in radius from Kushiro.

DISCUSSION

Common minke whales were mainly distributed in or close to the Oyashio first branch area where Pacific saury and Japanese common squid were mainly distributed. The results of previous three years in 2002, 2004, and 2005 indicated that Pacific saury was one of the abundant epipelagic small fishes in this study area in autumn (Kawahara et al. 2003, 2004, 2005). However, catches of this species were extremely low in 2006. Although this species were collected more abundantly in this year, its CPUE level was still lower than previous three years from 2003 to 2005. Japanese common squid were sometimes captured in this area and its CPUE was slightly higher than 2006 (Watanabe et al. 2007). Catch data of commercial squid fishing also supported this result. Considering these results, together with the result that Japanese anchovy were mainly distributed more inshore area than the main distribution area of common minke whale, prey environment of the whales seemed to be poor in terms of abundance of epipelagic small fish and squids, although it seems slightly better than 2006.

ACKNOWLEDGEMENT

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Table 1. Waypoints of planned track lines off Kushiro in 2007

WP	Latitude (ºN)	Longitude (ºE)	Area
H-1	41 º00.0'	142 º57.0'E	Off Hidaka
H-2	41 º09.0'	142 º30.0'	Off Hidaka
H-3	41 º24.0'	143 º15.5'	Off Hidaka
H-4	41 º39.0'	142 º30.0'	Off Hidaka
H-5	41 º53.0'	143 º12.0'	Off Hidaka
W-1	42 º12.0'	143 º27.0'	Coast West
W-2	41 º57.0'	144 º03.0'	Coast West
W-3	41 º42.0'	143 º15.0'	Coast West
W-4	41 º27.0'	143 º59.0'	Coast West
W-5	41 º12.0'	143 º15.0'	Coast West
W-6	41 º00.0'	143 º46.0'	Coast West
O-1	41 º00.0'	144 º17.0'	Offshore
O-2	42 º04.0'	144 º47.0'	Offshore
O-3	41 º00.0'	145 º17.0'	Offshore
O-4	42 º23.0'	145 º47.0'	Offshore
O-5	41 º00.0'	146 º17.0'	Offshore
O-6	41 º45.0'	146 º34.0'	Offshore
E-1	42 º46.0'	145 º53.0'	Coast East
E-2	42 º22.0'	145 º44.0'	Coast East
E-3	43 º03.0'	145 º29.0'	Coast East
E-4	42 º12.0'	145 º14.0'	Coast East
E-5	42 º56.0'	145 º00.0'	Coast East
C-1	42 º37.0'	145 º00.0'	Coast Central
C-2	42 º06.0'	144 º51.0'	Coast Central
C-3	42 º54.0'	144 º36.0'	Coast Central
C-4	41 º54.0'	144 º21.0'	Coast Central
C-5	42 º51.0'	144 º06.0'	Coast Central
C-6	42 º10.0'	143 º51.0'	Coast Central
C-7	42 º26.0'	143 º36.0'	Coast Central

Table 2. Sampling data (P: predetermined trawl; T: target trawl; OB: oblique tow; SH: surface layer horizontal tow; MH: midwater horizontal tow)

A. Trawl sampling

Stn	Survey region	Survey block	P/T	CTD	Towing method	Day/ Night	Date Year	Month	Day	SST (ºC)	Latitude Start Degree	Latitude Start Minute	N/S	Longitude Start Degree	Longitude Start Minute	E/W	Latitude End Degree	Latitude End Minute	N/S	Longitude End Degree	Longitude End Minute	E/W	Time Start H	Time Start M	Time End H	Time End M	Sampling depth (m) Shallowest	Sampling depth (m) Deepest	Sampling duration (min)
C-1	K	H	P	Y	OB	Day	2007	9	11	20.7	41	0	N	142	59.2	E	40	55.8	N	142	52.4	E	06	05	07	23	0	100	30
C-2	K	H	P	Y	SH	Day	2007	9	11	21.3	41	10.2	N	142	33.8	E	41	07.3	N	142	29.1	E	11	35	12	35	0	30	30
C-3	K	H	P	Y	OB	Day	2007	9	12	20.9	41	21.1	N	143	6.6	E	41	24.2	N	143	11.7	E	06	05	07	28	0	100	30
C-4	K	H	P	Y	SH	Day	2007	9	12	19.7	41	47.6	N	142	56.7	E	41	46.2	N	142	51.3	E	14	32	15	36	0	30	30
C-5	K	W	P	Y	SH	Day	2007	9	13	17.9	42	8.7	N	143	34.9	E	42	10.3	N	143	31.6	E	07	58	09	02	0	30	30
C-6	K	W	P	Y	OB	Day	2007	9	14	18.3	41	48.4	N	143	35.2	E	41	50.4	N	143	42.1	E	09	45	11	16	0	100	30
C-7	K	W	P	Y	SH	Day	2007	9	14	21.3	41	41.7	N	143	14.1	E	41	43.4	N	143	19	E	13	49	14	53	0	30	30
C-8	K	W	P	Y	OB	Day	2007	9	15	19.1	41	23.5	N	143	48.6	E	41	25.5	N	143	56.3	E	09	33	11	05	0	100	40
C-9	K	O	P	Y	SH	Day	2007	9	17	17.7	41	19.9	N	144	26.2	E	41	23.9	N	144	25.3	E	09	00	10	09	0	30	30
C-10	K	O	P	Y	OB	Day	2007	9	19	17.6	41	32.7	N	145	1.7	E	41	30.1	N	145	07.2	E	09	34	10	54	0	100	30
C-11	K	O	T	Y	SH	Day	2007	9	21	22.4	41	9.5	N	145	20.4	E	41	14.1	N	145	21.1	E	07	35	08	39	0	30	30
C-12	K	O	P	Y	SH	Day	2007	9	23	21.2	41	45	N	145	34	E	41	41.3	N	146	34	E	06	00	07	07	0	30	30
C-13	K	O	P	Y	OB	Day	2007	9	24	18.1	42	13	N	145	50.6	E	42	08	N	145	52	E	09	35	10	58	0	100	30
C-16	K	E	P	Y	SH	Day	2007	9	25	16.3	42	45.8	N	145	53	E	42	40.9	N	145	50.7	E	09	55	11	29	0	30	60
C-17	K	E	P	Y	SH	Day	2007	9	27	13.2	42	22	N	145	43.9	E	42	25.9	N	145	42	E	06	10	07	15	0	30	30
C-18	K	E	P	Y	SH	Day	2007	9	27	13.2	42	41.2	N	145	22.7	E	42	47.1	N	145	24.2	E	14	37	15	55	0	30	60
C-19	K	E	P	Y	OB	Day	2007	9	30	11.8	42	26.6	N	145	18.2	E	42	21.9	N	145	19.3	E	06	16	07	35	0	100	30
C-20	K	E	P	Y	SH	Day	2007	9	30	15.2	42	44.7	N	145	3.3	E	42	39.8	N	145	04.3	E	12	34	13	44	0	30	30
C-21	K	C	P	Y	SH	Day	2007	10	1	12.3	42	23.2	N	144	56.1	E	42	29.4	N	144	56.7	E	07	53	09	26	0	30	60
C-22	K	C	P	Y	SH	Day	2007	10	2	15.1	42	46.8	N	144	38.4	E	42	43.3	N	144	39.2	E	09	42	10	44	0	30	30
C-23	K	C	P	Y	OB	Day	2007	10	2	15.1	42	42.7	N	144	31.5	E	42	39.9	N	144	30.5	E	15	12	16	08	90	120	12
C-24	K	C	P	Y	SH	Day	2007	10	3	13.9	42	29.1	N	144	29.5	E	42	35.2	N	144	30.5	E	09	14	10	48	0	30	60
C-25	K	C	P	Y	SH	Day	2007	10	4	14.3	42	30.8	N	144	11.4	E	42	24.8	N	144	14.6	E	10	03	11	39	0	30	60
C-26	K	C	P	Y	SH	Day	2007	10	5	15.0	42	50.1	N	144	6.9	E	42	46.2	N	144	07.8	E	06	25	07	32	0	30	30
C-27	K	C	P	Y	SH	Day	2007	10	5	15.2	42	26	N	143	36.1	E	42	22.5	N	143	38.6	E	13	58	15	02	0	30	30
C-28	K	C	P	Y	SH	Day	2007	10	6	13.5	42	24.7	N	143	56.1	E	42	17.7	N	143	53.9	E	06	30	08	04	0	30	60
B. IKMT sampling																												
C-14	K	E	T	N	MH	Day	2007	9	25	16.2	42	43.4	N	145	51.9	E	42	42.5	N	145	50.6	E	6	50	7	40	60	80	30
C-15	K	E	T	Y	MH	Day	2007	9	25	15.3	42	42.1	N	145	51.6	E	42	45.2	N	145	53.5	E	7	55	9	15	160	180	30

Table 3. Result of sighting survey for large whales

	Primary sighting		Secondly sighting	
Species	Groups	Animals	Groups	Animals
Common minke whale	7	7	0	0
Bryde's whale	1	1	0	0
Sei whale	4	5	0	0
Fin whale	1	1	0	0
Sperm whale	6	6	1	1

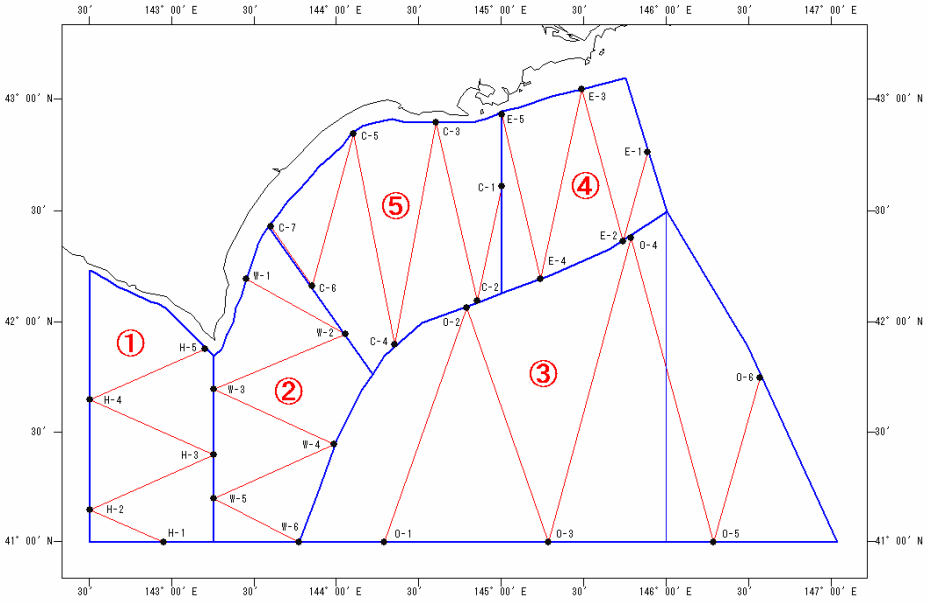

Fig. 1. Survey area and planned track lines of the prey species survey in 2007 off Kushiro. Whaling was conducted mainly within 30 (maximum 50) nautical miles from Kushiro. 1: off Hidaka; 2: coast west; 3: offshore; 4: coast east; 5: coast central

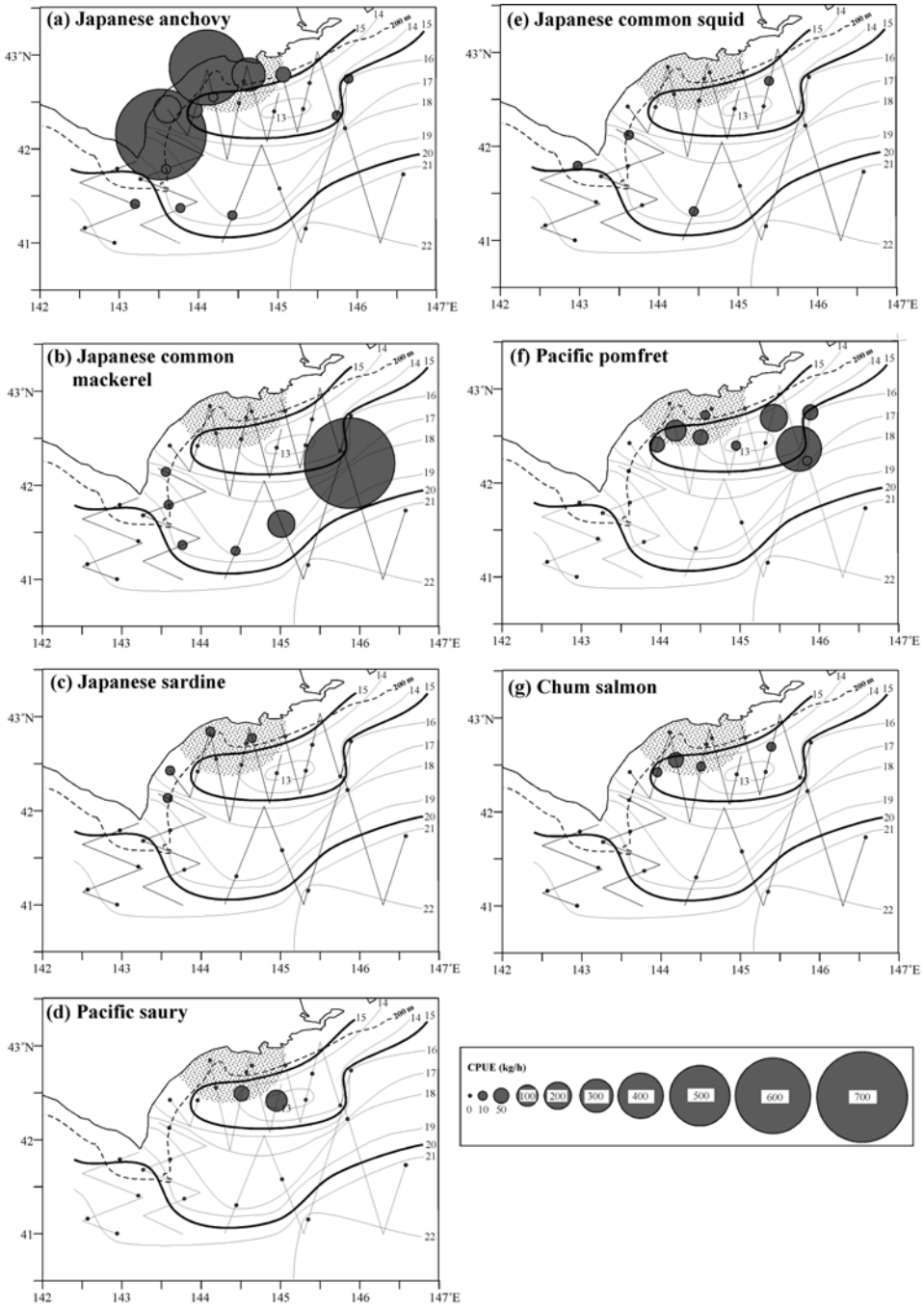

Fig. 2. Distributions of (a) Japanese anchovy, (b) Japanese common mackerel, (c) Japanese sardine, (d) Pacific saury, (e) Japanese common squid, (f) Pacific pomfret, and (g) Chum salmon based on the predetermined trawl samplings and distributions of isotherms at the sea surface off Kushiro in September and October 2007

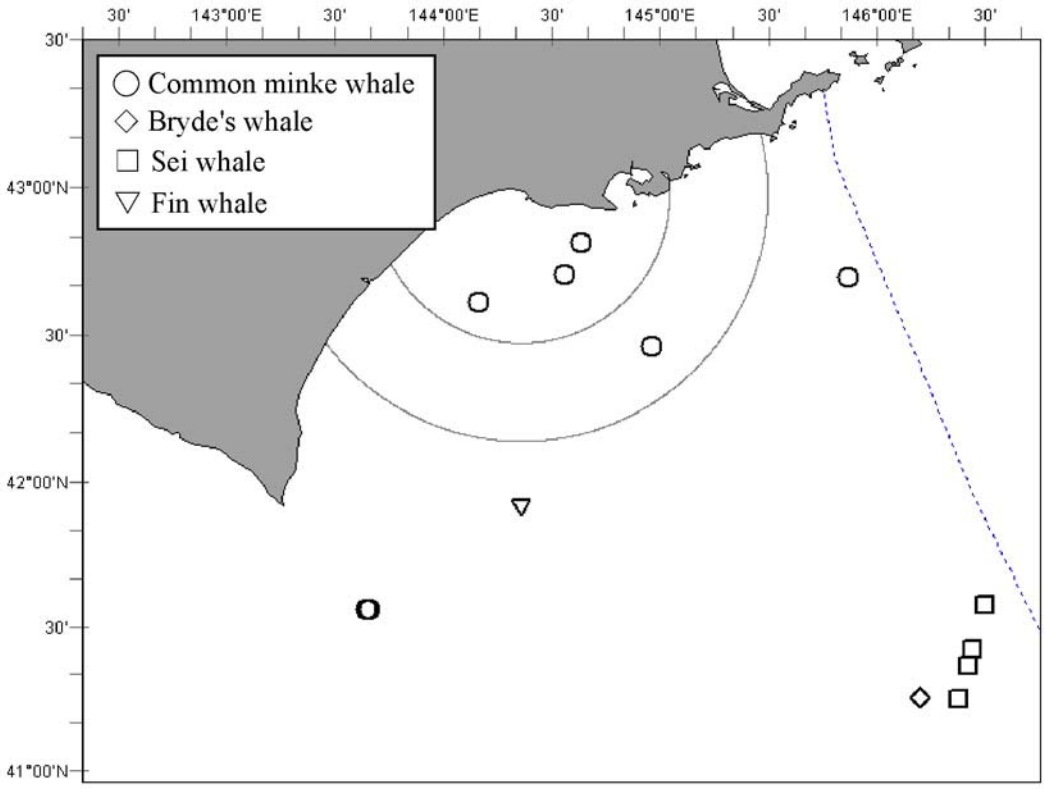

Fig. 3. Distribution of the major large whale species off Kushiro in 2007

Appendix 2

Oceanographic conditions in the JARPN II survey area off Kushiro, northeastern Japan, in September to October 2007

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ABSTRACT

A prey species survey for cetaceans was conducted off Kushiro in September to October 2007 using *Kaiko-Maru* as a part of coastal component of JARPN II. The survey covered a block where common minke whales were found. During the survey, oceanographic observation with CTD was made to make clear the environment of the prey. Water masses in the survey area have characteristics of the Cold water near the Oyashio except for several stations at western part of survey area where the Tsugaru warm water are observed.

Introduction

A prey species survey was conducted in the JARPN II area off Kushiro, western North Pacific from 9 September to 6 October 2007 using *Kaiko-Maru* in cooperation with the common minke whale sampling survey by small type whaling boats (Fig. 1).

There are a lot of water masses and fronts in the western North Pacific. The Oyashio flows southwestward along the Kuril Islands and turns eastward from the northeastern coast of Japan. The Kuroshio flows northward from the tropical area to Tohoku area, east of Japan, and reaches near the Oyashio front. Both major current, the Kuroshio and the Oyashio, form Kuroshio-Oyashio Inter-frontal Zone. Water masses originated in the Kuroshio and the Oyashio are mixed each other in this zone and form new water masses.

Each water mass in the western North Pacific 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 this area. In this paper, distributions of water masses and fronts in the survey area will be described to make clear the

environment for the prey of common minke whales.

Data and Methods

Hydrographic observations with a conductivity-temperature-depth profiler (CTD; SBE 19) were carried out from September 9 to October 6 in the survey area off Kushiro using *Kaiko-Maru* (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, because they are obscure in sea surface temperature distributions from summer to fall and the Oyashio water spreads into the subsurface layer (Table 1). Axis of the Kuroshio Extension is defined by the 14 isotherm at the depth of 200m (Kawai , 1969). The warm water spread from Kuroshio Extension is defied by temperature more than 10 at the depth of 100 m . The first and the second Oyashio Intrusions are defined by temperature less than 5 at the depth of 100 m (Murakami, 1994). We use these indices to know the distribution of water mass in the survey area.

The oceanographic conditions in September to October 2007 are detected by 100 m and 200 m temperature maps using the monthly mean subsurface temperature from NEAR-GOOS (the North-East Asian Regional-Global Ocean Observing System) database.

Oceanographic conditions in the survey area

Figure 2 shows the Temperature-Salinity diagrams in the survey area. There is no typical Kuroshio water characterized by high salinity profile around 34.5 psu, but a little high salinity water around 34.0 psu which is a warm water modified by the Tsugaru warm water (Fig. 2). The dominant water mass in Fig. 2 is the Oyashio water, which is characterized by cold (less than 5) and low salinity (less than 34.0 psu).

Figure 3 shows temperature and salinity maps at the depth of 100 m and 200 m. The middle and northeastern areas in Fig.3 have characteristics of the cold (less than 5) and low salinity (over 33.5 psu) water, especially at the 100 m depth. There is the warm high-salinity Tsugaru warm water at the western part of Fig.3. Both of temperature and salinity fronts lie between the Tsugaru warm water and the Oyashio water. Another temperature and salinity fronts, which is between the Oyashio water and the warm water spreading from the southern Kuroshio area, are observed at the southern part of Fig. 3.

Figure 4 shows the vertical sections of temperature, salinity and density anomaly along the line shown in Fig. 4. The warm water, warmer than 15 , is observed at the surface layer upper 20 m depth in southern observation area, and seasonal thermocline lies between 20 m and 100 m depth (upper panel at Fig. 4). All layers are occupied by low salinity water, less than 34 psu with the exception of southern upper layer at St. C12 (middle panel at Fig. 4). Density distribution (lower panel at Fig. 4) shows a shape like a dome at the middle area on this section. This high density water corresponds to the cold low-salinity Oyashio water.

Figure 5 shows the schematic hydrographic map in September 2007. The southern limit of the

1st Oyashio Intrusion moves southward from April to November. The position of the 1st Oyashio Intrusion in September 2007 was at 39ºN on 142º30'E line, which was a southward position from monthly mean location in September (40º20'N). Tsugaru warm water spread eastward to south of the Cape Erimo, and shows a front with the 1st Oyashio Intrusion. Almost all stations in the survey area were distributed in the Oyashio water defined by cold water (less than 5 ºC) at the depth of 100 m except for several stations (St. C1-C4) at the western part of the survey area.

REFERENCES

Kawai, H. (1969): Statistical estimation of isotherms indicative of the Kuroshio axis, *Deep-Sea Res.*, Suppl. to **16**, 109-115.

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℃ isotherm at 200 m
Warm-core ring	Temperature front at 200 m
Oyashio front	5 ℃ isotherm at 100 m
Oyashio water	Area with T<5 ℃ at 100 m
Cold water	Area with 5℃<T<10 ℃ at 100 m
Warm water	Area with T > 10ºC at 100 m and T < 14ºC at 200 m

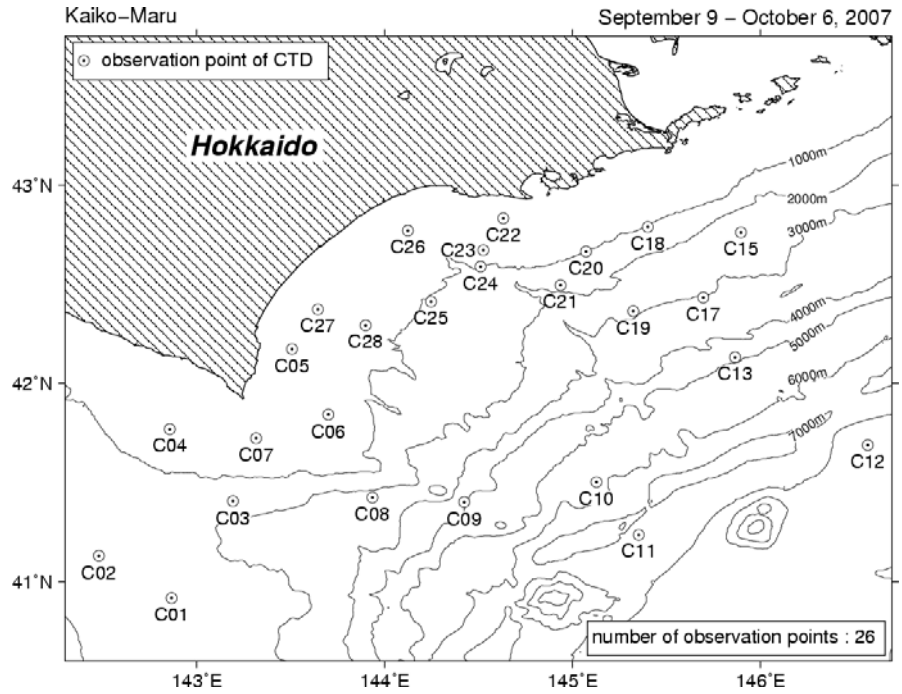

Fig. 1. Station map observed by *Kaiko-Maru* in September 9 to October 6, 2007

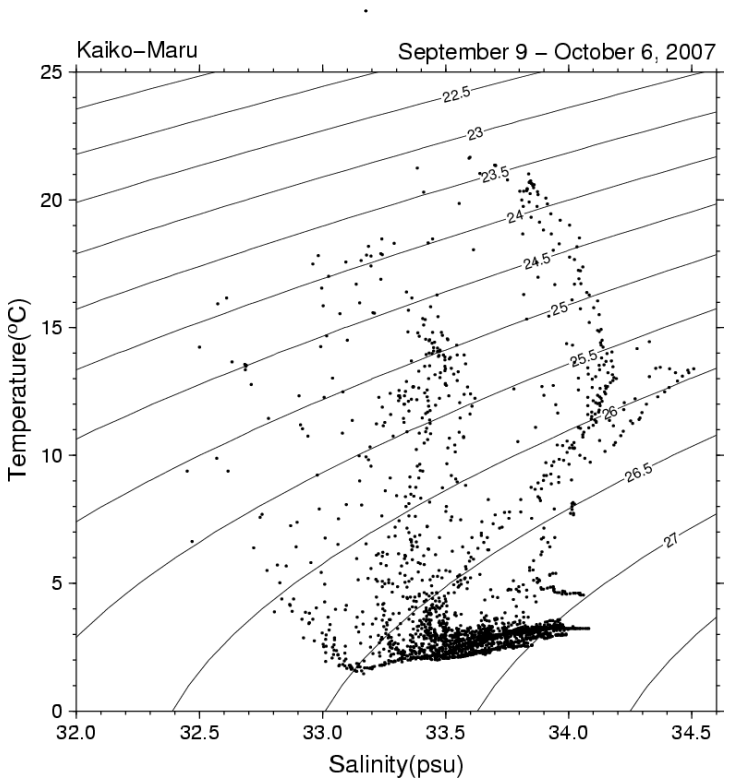

Fig. 2. Temperature-Salinity diagrams using CTD station data observed by *Kaiko-Maru* in September 9 to October 6, 2007. Each thin line in this figure denotes a density line of sigma-t.

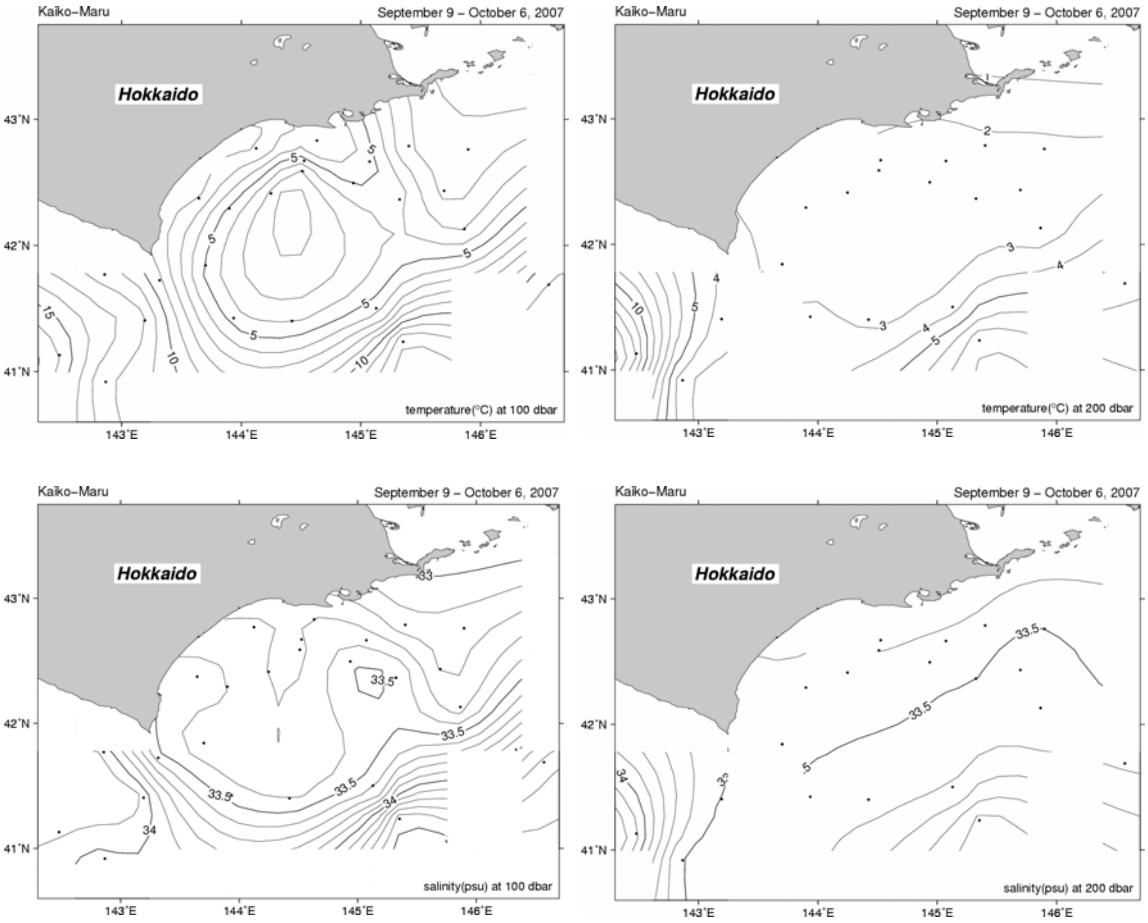

Fig. 3. 100 m temperature (left upper panel), 100 m salinity (left lower panel), 200 m temperature (right upper panel) and 200 m salinity (right lower panel) maps observed by *Kaiko-Maru* in September 9 to October 6, 2007.

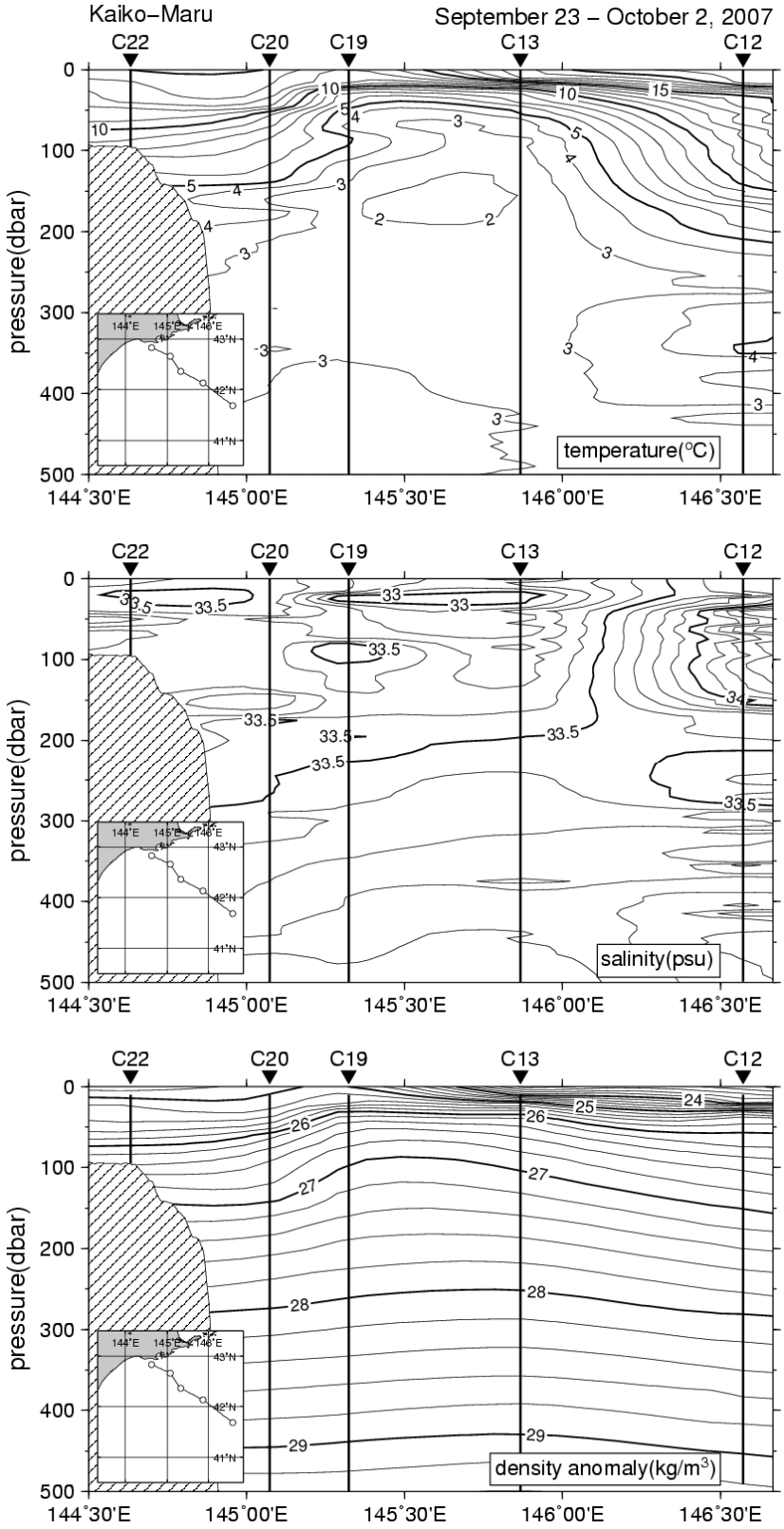

Fig. 4. Vertical sections of temperature (upper panel), salinity (middle panel) and density anomaly (lower panel) observed by *Kaiko-Maru* in September 9 to October 6, 2007.

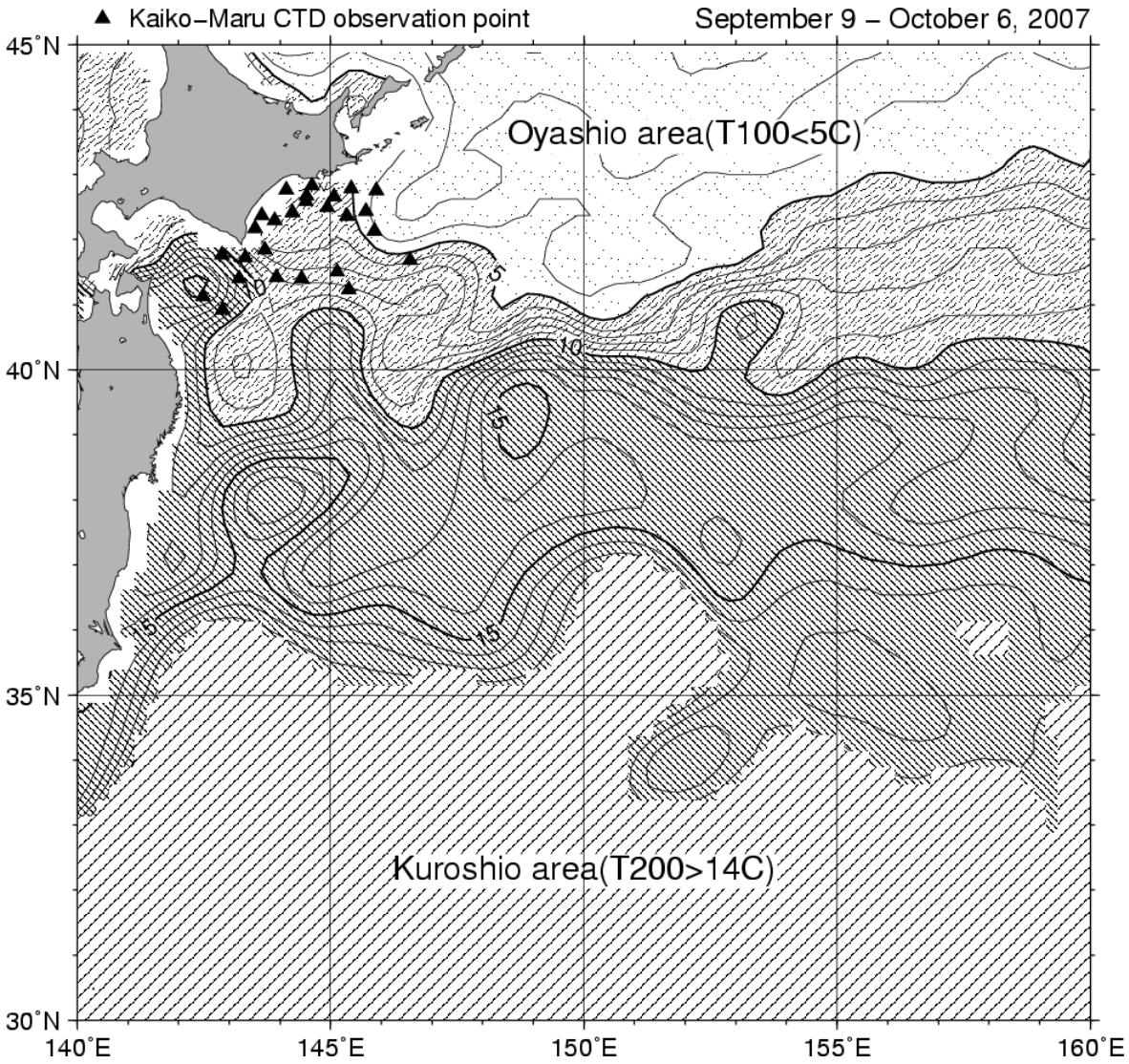

Fig. 5. Schematic hydrographic map in Tohoku area, northwestern Pacific, in September 2007 with station map observed by *Kaiko-Maru*.