Methodology and procedures of common minke whale's prey surveys in JARPN II –Coastal component of Kushiro–

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ABSTRACT: We describe the methodology of the surveys of the prey species of common minke whale *Balaenoptera acutorostrata* in the coastal component of the Research Program under Special Permit in the Western North Pacific (JARPN II). This research program is unique in that three survey components, prey species surveys, whale sighting surveys, and whale sampling surveys, were conducted concurrently within 50 nautical miles from Kushiro. Of these, the prey species surveys were conducted in both inshore and offshore regions of eastern Hokkaido off Kushiro in the autumn of 2002, 2004, 2005, 2006, and 2007 to estimate biomass of potential prey species of the common minke whale. Prey preference of the whales could be estimated based on this data and information of stomach contents of the whales. Knowledge on prey preference of cetaceans is essential not only to estimate inter-specific relationships in ecosystem models but also to clarify feeding strategy of the whales. To estimate abundance of prey species quantitatively, the study area was divided into five small blocks (coast east, coast central, coast west, off Hidaka, and offshore), and zigzag track lines were set in each block. The distribution and abundance of the prey species were investigated on these lines with the large sized midwater trawl, Isaacs-Kidd midwater trawl, and quantitative echosounder. In addition, a CTD cast was made down to 500 m depth at each sampling station to measure oceanographic conditions in this study area.

KEY WORDS: common minke whale, prey species survey, prey biomass, prey preference, autumn, coastal waters, Kushiro, JARPN II

1. INTRODUCTION

After two-year feasibility studies conducted in 2000 and 2001, a full-scale survey of the second phase of the Japanese Whale Research Program under Special Permit in the Western North Pacific (JARPN II) started in 2002. The objective of this program is (1) studying on feeding ecology of cetaceans and ecosystem modelling, (2) monitoring environmental pollutants in cetaceans and the marine ecosystem, and (3) elucidating stock structure of whales in the western North Pacific, especially within Japan's EEZ (Government of Japan, 2002a). This program would contribute to the conservation and sustainable use of marine living resources including marine mammals (Government of Japan, 2002a).

The results from the previous program JARPN (conducted from 1994 to 1999), and feasibility studies of JARPN II (conducted in 2000 and 2001) indicated that common minke whale *Balaenoptera acutorostrata* is one of the most abundant baleen whale species in the waters off eastern and southern Hokkaido during autumn (Government of Japan 2002b). Furthermore, they fed mainly on commercially important fish and squids such as Pacific saury *Cololabis saira*, Japanese anchovy *Engraulus japonicus*, walleye pollock *Theragra chalcogramma*, and Japanese common squid *Todarodes pacificus*, suggesting competitions between the whales and fisheries (Tamura and Fujise 2000).

Because the large whaling research vessel Nisshin Maru could not survey adequately in the coastal region especially in the near shore region, JARPN II established a new component, i.e. coastal component off Kushiro and Sanriku. In this component, common minke whales were sampled by small-type whaling boat. This research program is unique in that three surveys, prey species survey, whale sighting survey, and whale sampling survey were conducted concurrently in the same area. The objective of prey species survey off Kushiro is to examine geographical distribution patterns and biomass of each prey species of common minke whale in their habitat and estimate prey preference of the whale. In this document, we presented the research methodology of the prey species survey in the coastal component off Kushiro from 2002 to 2007. This survey was conducted by National Research Institute of Far Seas Fisheries (NRIFSF) and Institute of Cetacean Research (ICR).

2. METHODOLOGY OF PREY SURVEY

2.1 **Survey area and seasons**

Prey species surveys were conducted in the northern part of the sub-area 7 established by the IWC from 142º30’E to 147º00’E, and north of 41ºN except for Russian EEZ (Fig. 1). Because this area is a good fishing ground of Pacific saury, Japanese anchovy, Japanese common squid and walleye pollock, and southward migration pathway of common minke whale in autumn (Hatanaka and Miyashita 1997, Tamura and Fujise 2000), interaction between commercial fisheries and the whale is needed to investigate so as to determine the competition between them. In this area, both localities of fishing ground and catches of these commercially important fish and squids are greatly fluctuated by year because of remarkable annual changes in flow volume of the Oyashio and Kuroshio Currents (Kawai 1972, Hanawa et al. 1989). For instance, a formation of fishing ground of Pacific saury is closely related to Oyashio intrusion in autumn. Therefore, prey environment of common minke whale in this area thought to greatly change by year, which might affect distribution, abundance, and feeding habits of the whale.

We conducted prey species survey mainly in September (Table 1). During the survey, the sampling surveys of common minke whales were also conducted in the coastal waters within the 50 nautical miles from Kushiro (Kishiro et al. 2009). This means that prey species and whale sampling surveys were conducted concurrently. For the quantitative analysis of prey environment, the survey area was divided into one offshore and four coastal blocks: eastern, central, western and off Hidaka (Fig. 1).

2.2 Research vessels

The prey species survey was conducted by Kaiyo-Maru No. 3 of Nippon Kaiyo Co., Ltd. (474 GT) in 2002, Shunyo-Maru of NRIFSF (887 GT) in 2004, Kaiyo-Maru No. 7 of Nippon Kaiyo Co., Ltd. (499 GT), in 2005, and Kaiko-Maru of Kaiko Senpaku Co., Ltd. (860 GT) in 2006 and 2007, all of which were stern trawler-type research vessels.

2.3 Research method

All surveys were 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). As many fishing gears were set near the shore, the waters shallower than 50 m were principally excluded from the survey. Zigzag track lines were set in each small block of the study area. On these lines, the distribution and abundance of the prey species were investigated with the midwater trawl, Isaacs-Kidd midwater trawl (IKMT), and quantitative echosounder.

2.3.1. Net sampling

The midwater trawl adopted in this study had a mouth opening of about 30 x 30 m with a 17.5 mm liner cod end. The sampling depths and the height of the net mouth were monitored by net monitor system (PI32, SIMRAD) and/or the small-type temperature and depth recorders. Mouth opening and mesh size of the cod end of the IKMT was about 3.6 x 2.0 m and 1 mm, respectively. Towing speed was 3-4 knots for the midwater trawl and 2 knots for the IKMT.

A total of 133 midwater trawl survey was conducted (Table 1). Of these, the target trawls were made 15 times to identify species and size compositions of acoustic backscatters (Table 2). Target trawls were continued until targeted schools were captured through or maximum trawling duration reaches at 60 minutes. The results of target trawls were shown in Table 3. This indicates that the acoustic backscattering of the two major prey species, Japanese anchovy and walleye pollock, could be detected by our acoustic survey. Other 118 trawls were so-called ‘predetermined trawling’. Those were aimed to examine the distribution and abundance of squids and neustonic organisms like Pacific saury, which are difficult to detect by the echosounder (Tables 1 and 4-6). This trawling was made generally every 20 to 30 nautical miles on the track lines regardless of acoustic backscatters. At each predetermined station, a trawl net was towed at 0-100 m (oblique tow) or 0-30, or 30-60 m for 30 to 60 minutes in principal. 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 each individual was measured from randomly selected 100 individuals. When sample size was less than 100 individuals, body length was measured for all individuals. We also measured the total wet weight of these samples to estimate the total catch number for each sampling. Appropriate body length measurement methods were applies to each species: scale length for Japanese anchovy and Japanese sardine, knob length for Pacific saury, fork length for walleye pollock, mackerel, Pacific pomfret, and salmons, and dorsal mantle length for squids. For larval fish, notochord length was measured on preflection larvae, and standard length was measured on flection and postflection larvae.

IKMT samplings were conducted in 2002, 2006, and 2007 to identify the species and size compositions of the enphausiids in the 50-200 m layer (Tables 1 and 7). Samples were fixed in 10% buffered formalin seawater. For the major euphausiid species, 100 individuals were sorted out randomly and body length of each individual was measured.

Because acoustic data of Pacific saury and Japanese common squid is difficult to obtain, we estimated biomass of these species based on the trawl data. To estimate the distribution and biomass of Japanese common squid, we also used the data from the bottom trawl sampling conducted in the 100-250 m layer in the daytime by Hokkaido National Fisheries Research Institute. We also used this bottom trawl sampling data to estimate the distribution of walleye pollock. Furthermore, biomasses of the two minor epipelagic fishes, Japanese sardine and mackerel, and two large nektons, Pacific pomfret and chum salmon, were also estimated from trawl sampling data. Further detail was depicted in Watanabe et al. (2009).

2.3.2. Quantitative echosounder survey

We operated the quantitative echsounders, SIMRAD ER60 in 2002 and 2005, EK60 in 2004, ER500 and EK 500 in 2006 and 2007, by moving at about 10.5 knots on the track lines to acquire acoustic data with operating frequency at 38 and 120 kHz. Calibrations were carried out every year in the coastal region of shallow waters about 50 m depth in the study area using copper sphere technique. During the five years, a total of 4312 nautical miles was surveyed (Table 1). Acoustic data were analyzed with an aid of SonarData Echoview (Sonar Data Co., Ltd.) software. In principle, species identifications of backscatters were conducted based on the result of target trawling samplings (see below). In addition, information on school shapes of euphausiids (Miyashita et al. 1998), Japanese anchovy, and walleye pollock (Ohshimo and Hamatsu 1996) recorded on the echogram were also adopted in this study. For Japanese anchovy and walleye pollock, data collected at 38 kHz were used with the threshold set at –60 dB, and the depth range from 7 to 200 m. For euphausiids, data collected at 120 kHz were used with the threshold set at –80 dB. The analysed depth range was from 12 to 250 m. It was reported that echoes were identified as euphausiids if the difference of SV between 120 and 38 kHz was from 10 to 15 dB (Miyashita et al. 1997). To identify euphausiids, difference of SV was also calculated with a threshold of 38 kHz set at –80 dB. Biomass estimation was conducted according to the method of Jolly and Hampson (1990). Further detail was depicted in Watanabe et al. (2009).

2.3.3. Oceanographic observation

During 2004 and 2007, Conductivity-Temperature-Depth (CTD) profiler casts were made down to 500 m depth or near the bottom (< 500 m) at each sampling station to measure temperature and salinity profile in the study area. In 2002, CTD casts were conducted by sighting research vessel Kyoushin-Maru No. 2 in this study area. Details on oceanographic feature of this study area were reported by Okazaki et al. (2009).

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Table 1. Summary of prey species survey in the JARPN II coastal component off Kushiro.

			No. of towing			
		Total distance	Midwater trawl		IKMT	
Year	Survey period	of acoustic survey (nautical miles)	Targeting sampling	Predetermined sampling	Targeting sampling	No. of CTD cast
2002	10-29 September	825	8	35	2	*0
2004	24-29 September	322	0	14	0	14
2005	11-27 September	1393	5	27	0	54
2006	13-26 September	691	1	17	2	17
2007	11 September-6 October	1081	1	25	2	25
	Total	4312	15	118	6	110

*: CTD cast was made by sighiting survey vessel Kyoushin-Maru No. 2 at the same research area.

Table 2. Sampling data of target trawling survey in the JARPN II coastal component off Kushiro.

Year	Month	Day	Stn	Survey block	Towing method	Latitude Start Degree	Minute	N/S	Longitude Start Degree	Minute	E/W	Latitude End Degree	Minute	N/S	Longitude End Degree	Minute	E/W	Time Start H	M	Time End H	M	Sampling depth (m) Shallowest	Deepest	Sampling duration (min)
2002	9	15	9	C	SH	42	36.8	N	144	17.7	E	42	39.5	N	144	16.5	E	10	10	10	59	0	30	20
2002	9	15	10	C	MH	42	48	N	144	13.1	E	42	45.8	N	144	08.8	E	13	00	14	13	100	150	7
2002	9	16	12	C	MH	42	55.3	N	144	17.2	E	42	53.5	N	144	14.2	E	07	25	08	15	5	30	7
2002	9	16	13	C	MH	42	45.8	N	144	26.3	E	42	46.2	N	144	20.8	E	10	23	11	39	130	160	5
2002	9	17	17	C	MH	42	39.9	N	143	52	E	42	38.2	N	143	49.4	E	15	03	15	41	10	40	5
2002	9	18	18	C	MH	42	33.1	N	143	52.9	E	42	30.1	N	143	54.1	E	12	20	13	25	70	100	6
2002	9	21	24	E	SH	42	27.2	N	145	35.2	E	42	30.2	N	145	35.4	E	13	00	13	53	0	30	30
2002	9	27	40	O	SH	41	26.5	N	144	27.2	E	41	23.2	N	144	30.6	E	15	40	16	36	0	30	30
2005	9	13	7	W	MH	42	15.3	N	143	29.9	E	42	18.5	N	143	31.2	E	11	00	11	57	30	60	30
2005	9	20	27	E	MH	42	58	N	145	13.6	E	42	58.4	N	145	16.6	E	08	35	09	15	30	60	15
2005	9	21	35	C	SH	42	51.7	N	144	52.7	E	42	51.2	N	144	49.2	E	14	57	15	35	0	20	15
2005	9	22	37	C	SH	42	6.5	N	144	44.1	E	42	04.5	N	144	45.0	E	06	44	07	24	0	30	20
2005	9	23	42	C	SH	42	50.7	N	144	6.1	E	42	51.3	N	144	08.2	E	06	20	06	53	0	30	10
2006	9	17	8	C	MH	42	53.4	N	144	18.6	E	42	45.9	N	144	16.2	E	09	17	11	06	0	30	50
																						120	150	7
2007	9	21	C-11	O	SH	41	9.5	N	145	20.4	E	41	14.1	N	145	21.1	E	07	35	08	39	0	30	30

Table 3. Species composition of target trawl samplings that were collected more than 10 kg in total catch.

Year	Stn	Sampling depth (m)	Species composition (% WW)							Total catch (kg)
			Japanese anchovy	Walleye pollock	Pacific saury	Mackerels	Common squid	Mycto-phidae	Others	
2002	9	0-30	100	-	-	-	-	-	-	45.6
2002	12	0-30	100	-	-	-	-	-	-	625.4
2002	17	10-40	98.4	-	1.6	-	-	-	-	22.3
2002	18	70-100	93.7	-	-	-	-	-	0.2	364.6
2002	40	0-30	100	-	-	-	-	-	-	181.0
2002	10	100-150	-	76.4	-	-	23.5	-	0.1	1655.5
2002	13	130-160	-	97.3	-	-	0.1	2.4	0.2	762.8
2005	35	0-30	99.3	-	-	0.7	-	-	-	175.3
2005	42	0-30	99.1	-	-	0.9	-	-	-	84.3
2006	8	0-30	100	-	-	-	-	-	-	44.5
2006	8	120-150	-	92.9	-	-		-	7.1	391.8

Table 4. Sampling data of predetermined trawl survey in 2002.

Year	Month	Day	Stn	Survey block	Towing method	Latitude Start Degree	Minute	N/S	Longitude Start Degree	Minute	E/W	Latitude End Degree	Minute	N/S	Longitude End Degree	Minute	E/W	Time Start H	M	Time End H	M	Sampling depth (m) Shallowest	Deepest	Sampling duration (min)
2002	9	10	1	C	SH	42	28.6	N	144	46.7	E	42	26.6	N	144	43	E	16	05	17	06	0	30	30
2002	9	11	2	C	OB	42	22.2	N	144	56.1	E	42	26.9	N	144	58.3	E	07	18	08	51	0	100	60
2002	9	11	3	C	OB	42	43.1	N	144	59.2	E	42	37.6	N	144	57.6	E	11	54	13	25	0	100	60
2002	9	11	3	C	OB	42	43.1	N	144	59.2	E	42	37.6	N	144	57.6	E	11	54	13	25	0	100	60
2002	9	14	5	C	OB	42	47	N	144	46	E	42	47	N	144	37	E	06	38	08	29	0	100	60
2002	9	14	6	C	OB	42	30.9	N	144	39	E	42	24.2	N	144	38.3	E	10	22	12	07	0	100	60
2002	9	14	7	C	OB	42	5.3	N	144	39	E	41	59.6	N	144	38.6	E	13	59	15	35	0	100	60
2002	9	15	11	C	OB	42	47.2	N	144	10.7	E	42	41.8	N	144	11.6	E	14	48	16	34	0	100	60
2002	9	16	14	C	OB	42	25.1	N	144	15.5	E	42	19.2	N	144	16.6	E	14	20	15	54	0	100	60
2002	9	17	15	C	OB	42	1.5	N	144	20.3	E	42	04.2	N	144	14.8	E	07	05	08	44	0	100	60
2002	9	17	16	C	SH	42	11.1	N	144	12.8	E	42	12.2	N	144	09.6	E	10	19	11	13	0	30	20
2002	9	18	19	C	OB	42	15.8	N	144	0.3	E	42	10.4	N	144	02.4	E	14	49	16	25	0	100	60
2002	9	19	20	W	OB	41	47.7	N	144	12	E	41	48.8	N	144	05.4	E	08	48	10	15	0	100	60
2002	9	19	21	W	SH	41	50.9	N	143	50.3	E	41	51.8	N	143	46.9	E	11	22	12	08	0	30	20
2002	9	21	22	E	SH	42	35.6	N	145	15.2	E	42	33.6	N	145	17.4	E	07	59	08	55	0	30	30
2002	9	21	23	E	OB	42	22.2	N	145	31.5	E	42	19.2	N	145	36	E	10	34	12	06	0	100	60
2002	9	21	25	E	SH	42	47.2	N	145	38.3	E	42	50.8	N	145	39.2	E	15	30	16	26	0	30	30
2002	9	22	26	E	OB	42	58.1	N	145	40.1	E	42	52.9	N	145	37.6	E	07	07	08	43	0	100	60
2002	9	22	28	O	OB	42	31	N	145	59.9	E	42	25.6	N	145	58.6	E	13	10	14	43	0	100	60
2002	9	23	29	O	SH	42	1.1	N	145	51.4	E	41	58	N	145	49.9	E	07	56	08	52	0	30	30
2002	9	23	30	O	OB	41	31.9	N	145	42.7	E	41	27.2	N	145	41.2	E	11	37	13	14	0	100	60
2002	9	24	31	O	OB	41	0	N	145	35.9	E	40	59.3	N	145	30.8	E	07	52	09	23	0	100	60
2002	9	24	32	O	SH	41	34.3	N	145	21.3	E	41	37.1	N	145	20.2	E	13	17	14	09	0	30	30
2002	9	25	33	O	OB	41	56.1	N	145	12.4	E	42	00.7	N	145	10.5	E	06	14	07	45	0	100	60
2002	9	25	34	O	SH	42	7.9	N	145	8.5	E	42	09	N	145	05.2	E	08	41	09	33	0	30	30
2002	9	26	35	O	OB	41	47	N	144	59.3	E	41	40.7	N	144	57.3	E	08	38	10	08	0	100	60
2002	9	26	36	O	SH	41	24.1	N	144	50.3	E	41	21.1	N	144	49.2	E	11	49	12	40	0	30	30
2002	9	26	37	O	OB	40	59.9	N	144	42.1	E	41	03.7	N	144	39.9	E	14	50	16	21	0	100	60
2002	9	27	38	O	OB	41	22.3	N	144	29.4	E	41	26	N	144	27.7	E	08	39	10	12	0	100	60
2002	9	27	39	O	SH	41	47.4	N	144	15.9	E	41	44.3	N	144	17.1	E	12	40	13	29	0	30	30
2002	9	28	41	O	SH	41	24.2	N	144	3.7	E	41	22.5	N	144	02.8	E	08	47	09	35	0	30	30
2002	9	28	42	O	OB	41	0.3	N	143	50.5	E	41	02.9	N	143	44.9	E	12	14	13	42	0	100	60
2002	9	28	43	W	SH	40	59.2	N	143	31.7	E	41	01	N	143	28.6	E	14	49	15	37	0	30	30
2002	9	29	44	W	OB	41	28.7	N	143	28.9	E	41	21.9	N	143	30.4	E	07	10	08	42	0	100	60
2002	9	29	45	W	SH	41	54.7	N	143	27.9	E	41	51.2	N	143	26.1	E	12	40	13	31	0	30	30

Table 5. Sampling data of predetermined trawl survey in 2004 and 2005.

Year	Month	Day	Stn	Survey block	Towing method	Latitude Start Degree	Minute	N/S	Longitude Start Degree	Minute	E/W	Latitude End Degree	Minute	N/S	Longitude End Degree	Minute	E/W	Time Start H	M	Time End H	M	Sampling depth (m) Shallowest	Deepest	Sampling duration (min)
2004	9	24	10	C	OB	42	45.3	N	144	25	E	42	48.2	N	144	19.0	E	16	33	18	0	0	150	30
2004	9	25	11	C	OB	42	43.4	N	144	28.1	E	42	37.4	N	144	24.5	E	8	23	9	58	0	120	30
2004	9	25	12	C	SH	42	24.6	N	144	33.1	E	42	20.2	N	144	29.9	E	13	30	14	36	0	30	30
2004	9	26	15	C	OB	42	38.1	N	144	3.3	E	42	33.7	N	143	57.1	E	9	26	11	0	0	170	30
2004	9	26	16	C	SH	42	24.5	N	144	5.7	E	42	25.2	N	143	59.9	E	13	30	14	24	0	30	30
2004	9	26	17	C	OB	42	14	N	144	9.9	E	42	14.8	N	144	3.8	E	16	18	17	58	0	110	30
2004	9	27	19	E	OB	42	38.2	N	145	5.2	E	42	43.3	N	145	2.1	E	10	12	11	36	0	170	30
2004	9	27	20	E	SH	42	24.4	N	145	11	E	42	20.4	N	145	13.1	E	14	3	15	7	0	30	30
2004	9	27	21	E	OB	42	11.7	N	145	14.7	E	42	13.9	N	145	10.6	E	16	11	17	33	0	120	30
2004	9	28	23	E	OB	42	49.1	N	145	34.4	E	42	52.5	N	145	26.3	E	09	34	11	07	0	160	30
2004	9	28	24	E	SH	42	35.9	N	145	40.2	E	42	38.7	N	145	36.1	E	13	45	14	46	0	30	30
2004	9	28	25	E	OB	42	26.2	N	145	43.5	E	42	29.8	N	145	39.4	E	16	16	17	29	0	150	30
2004	9	29	27	W	OB	42	1.3	N	144	0.8	E	42	02.1	N	143	54.9	E	11	11	12	26	0	120	30
2004	9	29	28	W	OB	42	0.3	N	143	45.2	E	42	01.6	N	143	37.9	E	13	54	15	23	0	190	30
2005	9	11	2	C	SH	42	36.8	N	143	59.4	E	42	34.5	N	143	55.9	E	16	53	17	39	0	30	20
2005	9	12	3	C	OB	42	17.2	N	144	5.1	E	42	20.2	N	144	08.2	E	08	32	09	35	0	100	30
2005	9	12	4	C	SH	41	55.7	N	144	11	E	41	57.8	N	144	14.2	E	12	31	13	22	0	30	30
2005	9	12	5	W	SH	41	56.7	N	144	0.6	E	41	55.0	N	144	03.5	E	16	20	17	00	0	30	20
2005	9	13	8	W	OB	41	54.6	N	143	43.3	E	41	57.4	N	143	45.0	E	14	43	15	39	0	100	30
2005	9	14	10	C	OB	42	34.6	N	144	9.2	E	42	32.1	N	144	11.7	E	07	39	08	36	0	100	30
2005	9	14	11	C	SH	42	23	N	144	22.5	E	42	25.5	N	144	18.6	E	10	43	11	39	0	30	20
2005	9	14	12	C	SH	42	5.9	N	144	42.1	E	42	07.0	N	144	37.5	E	14	47	15	29	0	30	20
2005	9	16	15	O	OB	41	25.1	N	145	10.2	E	41	22.4	N	145	12.7	E	11	25	12	21	0	100	30
2005	9	17	17	O	OB	42	17.1	N	145	30.3	E	42	14.4	N	145	28.6	E	07	06	08	02	0	100	30
2005	9	17	18	O	OB	41	36.1	N	145	46	E	41	33.2	N	145	44.6	E	12	34	13	25	0	100	30
2005	9	18	20	O	OB	42	29.8	N	145	0.3	E	41	30.5	N	145	56.2	E	06	27	07	38	0	100	30
2005	9	18	21	E	SH	42	41.9	N	145	48.6	E	42	42.7	N	145	53.3	E	09	43	10	34	0	30	30
2005	9	18	22	E	SH	42	51.9	N	145	39.4	E	42	49.8	N	145	42.8	E	12	29	13	23	0	30	30
2005	9	19	24	E	SH	42	55.2	N	145	31.7	E	42	56.2	N	145	35.4	E	07	02	07	54	0	30	30
2005	9	19	25	E	OB	42	41.9	N	145	37.6	E	42	43.1	N	145	42.0	E	10	12	11	07	0	100	30
2005	9	19	26	E	SH	42	30.3	N	145	40.5	E	42	28.3	N	145	43.5	E	15	06	15	49	0	30	20
2005	9	20	28	E	SH	42	54.5	N	145	15.4	E	42	55.5	N	145	18.1	E	10	22	11	09	0	30	20
2005	9	21	31	E	OB	42	30.4	N	145	9.3	E	42	33.1	N	145	07.7	E	08	18	09	14	0	100	30
2005	9	21	32	E	SH	42	40.2	N	145	5	E	42	43.0	N	145	06.5	E	10	52	11	43	0	30	30
2005	9	22	38	C	SH	42	39	N	144	34.3	E	42	38.0	N	144	29.6	E	10	52	11	43	0	30	30
2005	9	23	44	C	OB	42	44.5	N	144	9.2	E	42	40.2	N	144	04.3	E	12	55	14	13	30	150	45
2005	9	23	48	C	OB	42	44.9	N	144	25.9	E	42	41.3	N	144	29.1	E	14	03	15	24	30	170	45
2005	9	25	50	C	OB	42	26.4	N	143	58.3	E	41	23.9	N	144	01.1	E	10	00	10	58	0	100	30
2005	9	25	51	C	SH	41	37.4	N	143	33.4	E	41	35.9	N	143	36.3	E	13	59	14	42	0	30	20
2005	9	27	53	C	OB	41	37.3	N	143	19.6	E	41	34.2	N	143	22.7	E	07	45	08	50	80	170	30
2005	9	27	54	C	SH	41	17.4	N	143	33.2	E	41	19.4	N	143	30.3	E	12	23	13	04	0	30	20

Table 6. Sampling data of predetermined trawl survey in 2006 and 2007.

Year	Month	Day	Stn	Survey block	Towing method	Latitude Start Degree	Minute	N/S	Longitude Start Degree	Minute	E/W	Latitude End Degree	Minute	N/S	Longitude End Degree	Minute	E/W	Time Start H	M	Time End H	M	Sampling depth (m) Shallowest	Deepest	Sampling duration (min)
2006	9	13	3	W	SH	41	29.1	N	143	25.8	E	41	30.7	N	143	30.2	E	07	03	08	18	0	30	40
2006	9	13	4	W	OB	41	39.1	N	144	0	E	41	46.9	N	143	59.1	E	13	33	15	47	0	100	60
2006	9	14	5	W	OB	42	5.7	N	143	38.8	E	42	09.7	N	143	47	E	09	03	10	57	0	100	60
2006	9	16	6	C	OB	42	0.7	N	144	2.2	E	41	55.2	N	144	04.1	E	09	09	10	52	0	100	60
2006	9	16	7	C	SH	42	28.9	N	144	12.3	E	42	32.6	N	144	14	E	14	35	15	41	0	30	30
2006	9	18	9	C	OB	42	18.9	N	144	28.8	E	42	14.5	N	144	29.1	E	06	05	07	41	0	100	45
2006	9	19	10	O	OB	41	7.5	N	144	39.8	E	41	02.2	N	144	37.9	E	14	32	16	11	0	100	60
2006	9	21	11	E	SH	42	39.8	N	145	54.9	E	42	42.1	N	145	57.3	E	06	05	07	18	0	30	30
2006	9	21	12	E	SH	42	59.3	N	145	45.6	E	42	58.6	N	145	41.5	E	14	02	14	48	0	30	15
2006	9	22	13	E	OB	42	43.5	N	145	33.2	E	42	38.4	N	145	29	E	07	07	08	48	0	100	60
2006	9	22	14	E	SH	42	14.1	N	145	24.7	E	42	15.4	N	145	26.1	E	12	12	12	52	0	30	5
2006	9	23	15	E	SH	42	38.4	N	145	15.4	E	42	41.3	N	145	17.4	E	06	05	07	00	0	30	30
2006	9	23	16	E	SH	42	39.3	N	145	4.3	E	42	35.4	N	145	01.7	E	14	06	15	15	0	30	30
2006	9	24	17	E	OB	42	24.3	N	145	0	E	42	17.1	N	144	59.2	E	07	58	09	37	0	100	45
2006	9	24	18	C	SH	42	51.1	N	144	48.6	E	42	50.2	N	144	44	E	14	21	15	16	0	30	30
2006	9	25	19	C	SH	42	30.2	N	144	42.6	E	42	27.4	N	144	42.9	E	14	11	15	20	0	30	30
2006	9	26	20	C	OB	42	0.7	N	144	35	E	42	04.6	N	144	41.5	E	09	12	10	57	0	100	45
2007	9	11	C-1	H	OB	41	0	N	142	59.2	E	40	55.8	N	142	52.4	E	06	05	07	23	0	100	30
2007	9	11	C-2	H	SH	41	10.2	N	142	33.8	E	41	07.3	N	142	29.1	E	11	35	12	35	0	30	30
2007	9	12	C-3	H	OB	41	21.1	N	143	6.6	E	41	24.2	N	143	11.7	E	06	05	07	28	0	100	30
2007	9	12	C-4	H	SH	41	47.6	N	142	56.7	E	41	46.2	N	142	51.3	E	14	32	15	36	0	30	30
2007	9	13	C-5	W	SH	42	8.7	N	143	34.9	E	42	10.3	N	143	31.6	E	07	58	09	02	0	30	30
2007	9	14	C-6	W	OB	41	48.4	N	143	35.2	E	41	50.4	N	143	42.1	E	09	45	11	16	0	100	30
2007	9	14	C-7	W	SH	41	41.7	N	143	14.1	E	41	43.4	N	143	19	E	13	49	14	53	0	30	30
2007	9	15	C-8	W	OB	41	23.5	N	143	48.6	E	41	25.5	N	143	56.3	E	09	33	11	05	0	100	40
2007	9	17	C-9	O	SH	41	19.9	N	144	26.2	E	41	23.9	N	144	25.3	E	09	00	10	09	0	30	30
2007	9	19	C-10	O	OB	41	32.7	N	145	1.7	E	41	30.1	N	145	07.2	E	09	34	10	54	0	100	30
2007	9	23	C-12	O	SH	41	45	N	145	34	E	41	41.3	N	146	34	E	06	00	07	07	0	30	30
2007	9	24	C-13	O	OB	42	13	N	145	50.6	E	42	08	N	145	52	E	09	35	10	58	0	100	30
2007	9	25	C-16	E	SH	42	45.8	N	145	53	E	42	40.9	N	145	50.7	E	09	55	11	29	0	30	60
2007	9	27	C-17	E	SH	42	22	N	145	43.9	E	42	25.9	N	145	42	E	06	10	07	15	0	30	30
2007	9	27	C-18	E	SH	42	41.2	N	145	22.7	E	42	47.1	N	145	24.2	E	14	37	15	55	0	30	60
2007	9	30	C-19	E	OB	42	26.6	N	145	18.2	E	42	21.9	N	145	19.3	E	06	16	07	35	0	100	30
2007	9	30	C-20	E	SH	42	44.7	N	145	3.3	E	42	39.8	N	145	04.3	E	12	34	13	44	0	30	30
2007	10	1	C-21	C	SH	42	23.2	N	144	56.1	E	42	29.4	N	144	56.7	E	07	53	09	26	0	30	60
2007	10	2	C-22	C	SH	42	46.8	N	144	38.4	E	42	43.3	N	144	39.2	E	09	42	10	44	0	30	30
2007	10	2	C-23	C	OB	42	42.7	N	144	31.5	E	42	39.9	N	144	30.5	E	15	12	16	08	90	120	12
2007	10	3	C-24	C	SH	42	29.1	N	144	29.5	E	42	35.2	N	144	30.5	E	09	14	10	48	0	30	60
2007	10	4	C-25	C	SH	42	30.8	N	144	11.4	E	42	24.8	N	144	14.6	E	10	03	11	39	0	30	60
2007	10	5	C-26	C	SH	42	50.1	N	144	6.9	E	42	46.2	N	144	07.8	E	06	25	07	32	0	30	30
2007	10	5	C-27	C	SH	42	26	N	143	36.1	E	42	22.5	N	143	38.6	E	13	58	15	02	0	30	30
2007	10	6	C-28	C	SH	42	24.7	N	143	56.1	E	42	17.7	N	143	53.9	E	06	30	08	04	0	30	60

Table 7. Sampling data of IKMT survey.

Year	Month	Day	Stn	Survey block	Towing method	Latitude Start Degree	Minute	N/S	Longitude Start Degree	Minute	E/W	Latitude End Degree	Minute	N/S	Longitude End Degree	Minute	E/W	Time start H	M	Time end H	M	Sampling depth (m) Shallowest	Deepest	Sampling duration (min)
2002	9	15	8	C	MH	42	20.2	N	144	28.2	E	42	21.2	N	144	27	E	7	10	7	58	175	200	22
2002	9	22	27	E	MH	42	53.1	N	145	39.1	E	42	54.7	N	145	37	E	9	25	10	8	70	80	27
2006	9	26	21	O	OB	42	10.3	N	145	8.1	E	42	10.5	N	145	10.1	E	14	5	14	37	60	100	15
2006	9	26	22	O	OB	42	10	N	145	10.2	E	42	10.6	N	145	11.7	E	15	23	15	55	170	190	12
2007	9	25	C-14	E	MH	42	43.4	N	145	51.9	E	42	42.5	N	145	50.6	E	6	50	7	40	60	80	30
2007	9	25	C-15	E	MH	42	42.1	N	145	51.6	E	42	45.2	N	145	53.5	E	7	55	9	15	160	180	30

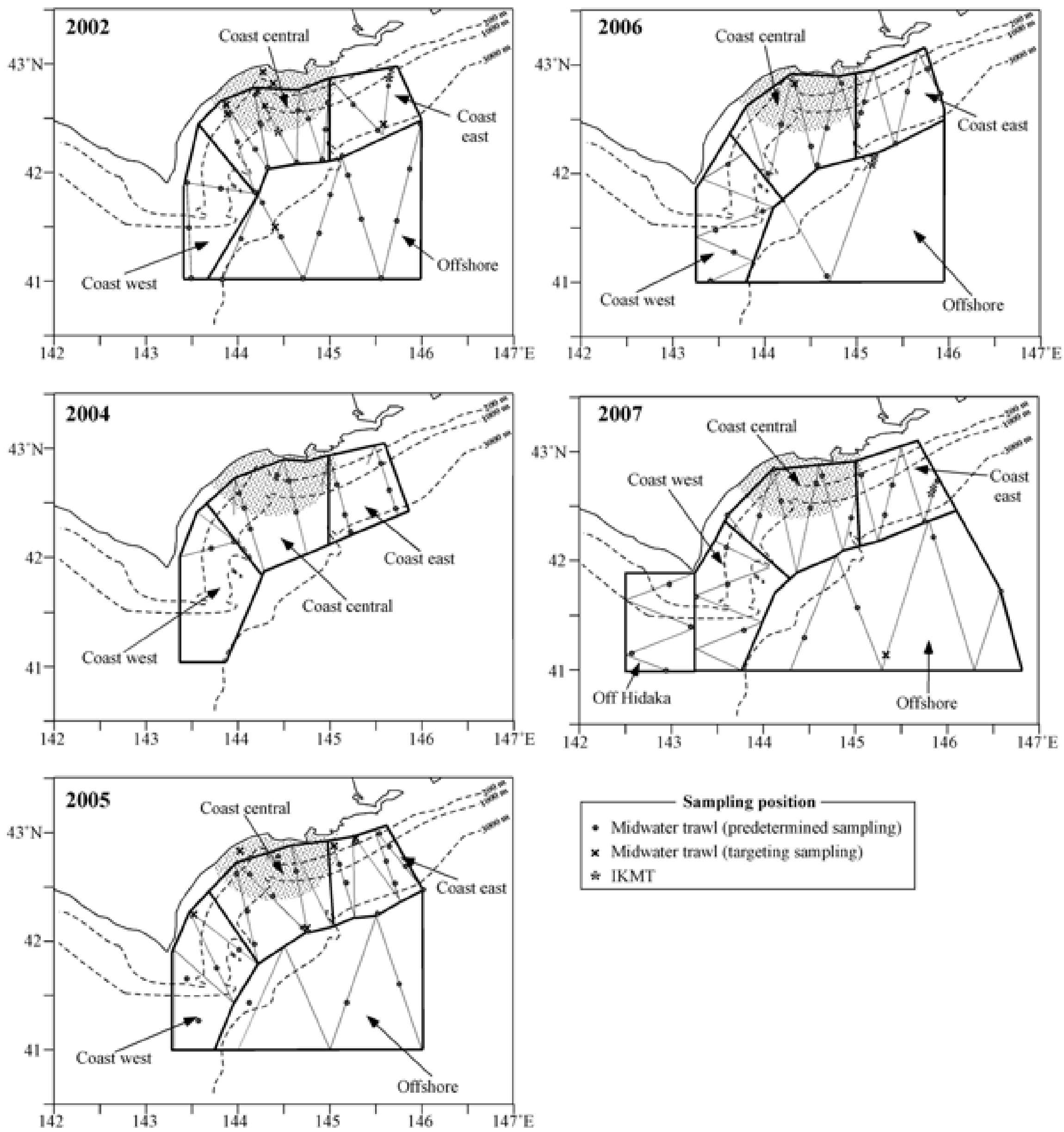

Fig. 1. Research area, small blocks, planned track lines, and sampling positions of prey survey in each year in the coastal component off Kushiro. Dotted area is sampling survey region of common minke whale. Dotted lines showed 200, 1000, and 3000 m isobath.