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INTERNATIONAL WHALING COMMISSION

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ABSTRACT

This paper reports the results of the biological sampling of Antarctic minke whales during the fourth New Scientific Whale Research Program in the Antarctic Ocean (NEWREP-A) conducted in Area III (0°-70°E, south of 60°S) during the 2018/19 austral summer season. The paper also reports the results of the sighting surveys and non-lethal experiments. Two sighting and sampling vessels (SSVs) and one research base vessel engaged in the survey for 72 days. A total of 362 sightings (involving 602 individuals) of Antarctic minke whale were made during 3,907 n.miles of searching distance. A total of 333 Antarctic minke whales (186 males and 147 females) were sampled, and a number of biological samples and data required for the two main objectives of NEWREP-A were obtained from each whale taken. In Area III-West, the survey was conducted early in the season (December to early February) for the first time since the start of JARPA survey in 1987/88. A total of 245 Antarctic minke whale (143 males and 102 females) were sampled in Area III-West. The obtained samples will contribute to elucidation of the stock structure of Antarctic minke whales, especially to elucidation of the western boundary of the Indian Ocean stock (I-stock). A total of eight southern right and 36 humpback whales were photo-identified and biopsy samples were collected from eight southern right, 29 humpback, two fin and one Antarctic minke whales in and transit to the research area. The samples and data collected in this survey are available for interested national and international scientists under the guidelines for research collaboration posted at the home page of the Institute of Cetacean Research (ICR): http://www.icrwhale.org/NEWREP-AProtocol.html.

KEYWORDS: SCIENTIFIC PERMITS; ANTARCTIC; FEEDING GROUNDS; ANTARCTIC MINKE WHALE; BIOPSY SAMPLING; PHOTO-ID

INTRODUCTION

The survey of the New Scientific Whale Research Program in the Antarctic Ocean (NEWREP-A) started in the 2015/16 austral summer season, after the review of the research plan by the International Whaling Commission Scientific Committee (IWC SC) following the guidelines in Annex P (IWC, 2015a; GOJ, 2016; Matsuoka *et al*., 2016).

The two main Objectives of NEWREP-A are I) Improvements in the precision of biological and ecological information for the application of the RMP to the Antarctic minke whales, and II) Investigation of the structure and dynamics of the Antarctic marine ecosystem through building ecosystem models.

Under Main Objective I, there are four sub-objectives as follows.

Objective I (i): Abundance estimates for Antarctic minke whales taking into account of g(0) and additional variance

Objective I (ii): Improvement of precision of biological and ecological parameters

Objective I (iii): Refinement of stock structure hypotheses of Antarctic minke whale in Areas III-VI for the implementation of the RMP

Objective I (iv): Specification of RMP ISTs for the Antarctic minke whales

Under Main Objective II, there are four sub-objectives as follows.

Objective II (i): Ecological Research (krill abundance estimation and oceanographic observation)

Objective II (ii): Abundance estimate of some cetacean species as input data for ecosystem modelling

Objective II (iii): Estimation of prey consumption by the Antarctic minke whale and its nutritional condition

Objective II (iv): Ecosystem modelling (Spatial interaction among baleen whales and consideration of predators-prey system and allometric reasoning)

Research under NEWREP-A requires the collection of various types of data and samples which are necessary for addressing main Objectives I and II of the program. For example, under Objective I (ii) samples and data related

to age, sexual maturity and body length of the whales are required. Under Objective I (iii), data and samples for studying morphometric, morphological and genetic differences among whales are required. All that information together with others obtained by non-lethal means (e.g. abundance under Objective I (i)) is necessary for the specifications of RMP *ISTs* for Antarctic minke whales (Objective I (iv)) will be used in the analysis.

Under Objective II (iii), stomach contents of the whales are required to estimate prey composition and consumption by Antarctic minke whales. Blubber thickness, fat weight and girth data are required to study the nutritional condition of the whales. All that information together with other obtained by non-lethal means (*e.g*. whale abundance under Objective II (ii) and krill biomass and oceanographic information under Objective II (i)) is necessary for the ecosystem modelling work (Objective II (iv)) will be used in the analysis.

Age data at the annual scale is required for the Statistical Catch-at-Age Analysis (SCAA) under objective I (ii). Age information can be obtained only from internal earplugs and therefore only through lethal sampling methods. The NEWREP-A review workshop agreed that at present, the technique commonly used for the determination of the biological parameters used in the SCAA model require earplugs for age determination (IWC, 2015b).

Calculation of sample size of Antarctic minke whale in NEWREP-A was based on the biological parameter, Age at Sexual Maturity (ASM). ASM is of great importance not only for contributing information on the proportion of matured animals in the SCAA (related to the main Objective I) but also as an important indicator of changes in the nutritional condition of the whale stock (related to main Objective II). The age-at-50% sexual maturity (ASM 50) was used to set the annual sample size of 333 Antarctic minke whales (see GOJ, 2015 for details).

The fourth whale sighting and sampling survey of the NEWREP-A was conducted in Area III (0°E-70°E) during the austral summer season 2018/19. Sighting and sampling survey in Area III-West was conducted for the first time since the start of JARPA survey in 1987/88. The objective of this paper is to present the results of the biological survey of 333 Antarctic minke whale sampled during the field survey of 2018/19 NEWREP-A. Sighting data obtained by the sighting and sampling vessels (SSVs) are also presented in Appendix.

The report of the dedicated sighting survey is presented by Mogoe *et al*. (2019) and that of the krill and oceanographic survey is presented by Wada *et al*. (2019).

SURVEY DESIGN

Research area

The research area of whale sighting and sampling survey was set as south of 60°S in Area III (0°-70°E, south of 60°S; Figure 1). The area was divided into the East and West sectors at 35°E (Figure 2). Each sector was divided into the South and North strata. The boundary between the South and North strata was defined by a line 45n.miles from the ice-edge. Estimated pack-ice line (ice-edge) was obtained from direct observation from the vessels and from the Defence Meteorological Satellite Program (DMSP; Maslanik and Stroeve, 1999).

Research vessels

Two sighting and sampling vessels (SSVs) *Yushin-Maru* (*YS1*) and *Yushin-Maru* No.3 (*YS3*) engaged in the sighting and sampling survey. They were equipped with a top barrel platform (TOP), upper bridge platform (UBP), and a whaling cannon. One researcher was on board on each SSV. Biological research of the sampled whales was carried out on board the research base vessel, *Nisshin-Maru* (*NM*). A total of nine researchers, including the cruise leader, were on board the *NM*.

Cruise track-line

Survey courses were established in offshore and ice edge strata of the research area by the line transect method. Two SSVs advanced along parallel track-lines 7n.miles apart (Main course and sub-course). Each of the SSVs changed the track-line order every day to avoid possible sighting bias by fixed position. Starting point of the day was set in principle at the position where one of the vessels ended the surveys on the previous day in the most advanced position. The other vessel moved to the starting position of the next day after the end of the daily survey.

The predetermined track-line of the sighting and sampling survey is shown in Figure 2. Track-line for each vessel consisted of two legs in the northern stratum at 1°40' longitudinal degree intervals, and four or six legs in the southern stratum at 1°40' longitudinal degree intervals in a 10° longitudinal band (Nishiwaki *et al*., 2014). Starting point of the survey was decided based on the pre-determined longitudinal or latitudinal line, which was selected

at random in the each stratum. The interval of legs and number of legs in each stratum could be changed in consideration of progress of the survey caused by weather conditions or other factors.

Sighting and sampling protocols

Sighting protocols were the same as those in IDCR/SOWER (Matsuoka *et al*., 2003). Research effort began 60 minutes after sunrise and ended 60 minutes before sunset, with a maximum 12 hour per day (approximately 06:00–18:00). Searching activity was conducted when the weather conditions were suitable for observations: minke whale visibility better than 1.5n.miles and the wind speed less than 21knots (northern stratum) or 26knots (southern stratum). Vessel speed during the sighting survey was 11.5knots with slight adjustment to avoid vibration of the vessels. Sighting effort was conducted from the TOP (three primary observers in the TOP) and the upper bridge.

Sample size for Antarctic minke whales was set as 333 animals (GOJ, 2015). Whales were sampled using a random sampling procedure (Kato *et al*., 1989). One or two minke whales were sampled randomly from each primary sighted school using harpoons with a 30g penthrite grenade. Sampled whales were immediately transported to the research base vessel, where biological measurements and sampling were carried out.

Biological measurements and sampling

Body proportion, blubber thickness and body weight

After photographing the lateral side of each whale, a series of standard measurements was taken, including body length to the nearest 1cm and body proportion at five different points (to the nearest 1cm). Skull measurements (length and breadth to the nearest 0.1cm) were taken using a large vernier calliper. Measurements of blubber thickness were taken at two points on the lateral side of the body. Girth dimensions at axilla and umbilicus were taken from all animals. Body weights of each whale were measured using an electronic track scale (EDP-1801 and EDI-911, Yamato Scale Co., Ltd., Japan) on board the *NM* to the nearest 0.01tons. Body parts and organs were weighed using an electronic hanging scale (Kubota) and a marine scale (M1100, Marel, Iceland).

Total fat weight

Blubber weight for assessment of nutritional condition was measured from one Antarctic minke whale on each survey day using an electronic hanging scale and a marine scale.

Definition of sexual maturity

The maturity of the females was determined by the presence of at least one corpus luteum or corpus albicans in either ovary. In the case where no corpus luteum or corpus albicans was observed, the female was categorized as immature. The definition of male sexual maturity was defined preliminary based on the weight of one testis. If the testis weight was over 400g, the whale was determined as sexually mature (Kato, 1986). Reproductive status of mature female whales was classified into five categories (ovulating, pregnant, resting, lactating and "pregnant and lactating"), based upon observations of ovary, uterus, and mammary gland. Pregnancy was defined based on conceptus with placental development in the uterus. Body length and weight of foetus was measured in the same way as for adult whales.

Sampling of earplugs

Left and right earplugs were collected for age determination by the routine procedure (Omura, 1963). After removing the mandibles, the external auditory meatus was exposed using a knife for subsequent incision. The external auditory meatus was carefully cut open so as not to incise the earplug, and then the earplug was collected with glove-finger using a scalpel. Earplugs were fixed and stored in 10% formalin neutral buffer solution.

Stomach contents

Conventional stomach content records (species, amount, size of krill) were obtained from all sampled whales. Stomach contents of the fore- and main-stomach were weighed for each whale. A part of contents were sampled, and then stored in 10% formalin solution or stored at −20°C for several analyses.

Other biological samples

As a supplement for age determination, the largest baleen plates were collected from whales with *V*-shape notch on their baleen plate and body length of less than 7m (Zenitani and Kato, 2010). Ocular lenses were collected from each whale and foetus, and stored at −80°C for age estimation. Ovaries were collected and stored at −20°C, and mammary glands were collected and stored in 10% formalin neutral buffer solution for reproductive study. Tissue samples of testes were collected and fixed using 10% formalin neutral buffer solution for the histological observation. After measurements of blubber thickness (two points), blubber samples were taken from all specimen for the study of feeding ecology. Muscle, liver and blubber samples were collected and stored at −20°C for pollutant studies. Skin samples were collected and fixed in ethanol solution (99%) for genetic studies.

RESULTS

Narrative of the cruise

Two SSVs (*YS1* and *YS3*) departed from Shimonoseki (Japan) and the *NM* departed from Innoshima on 12 November 2018 (Table 1). During transit from Japan to the research area, the sighting survey was conducted from 25 November to 10 December 2018 in the area between 15°S and 60°S outside of national EEZs. Two SSVs and one research base vessel engaged in the whale sighting and sampling survey for 72 days from 18 December 2018 to 27 February 2019. Sighting survey in medium/low latitude was conducted from 1 March to 12 March 2019 during transit from research area to Japan in the area between 15°S and 60°S outside of national EEZs. The *NM* arrived at Shimonoseki on 31 March 2019.

Geographical distribution of sampled whales

A total of 362 sightings (involving 602 individuals) of Antarctic minke whale were made by the two SSVs during survey period. Among then, a total of 333 Antarctic minke whales were caught. All whales were sampled in a random manner. Sighting positions of sampled whales are shown in Figure 3. Samples were collected from a wide range of the research area.

Sampling efficiency

A total of 333 whales was sampled from 356 targeted individuals. The technical sampling efficiency (number of sampled whales per number of targeted individuals) was 0.935. The main reason for missing was the quick movement of the whale (15 cases out of 23). Struck and lost occurred in one case.

Biological measurements and sampling

A total of 333 Antarctic minke whales (186 males and 147 females) were sampled, and a number of biological samples and data required for the two main objectives of NEWREP-A were obtained from each whale taken.

Sex and reproductive status of samples

Sex and reproductive status of sampled animals are shown in Table 2. Mature animals were dominant for males in the northern (71.6%) and southern (81.6%) strata of Area III-West. Mature animals were also dominant for females in the southern (59.7%) strata, however, immature animals were dominated in northern (72.0%) strata of Area III-West. In the eastern strata, maturity rate of males were high for both northern (54.5%) and southern (78.1%) strata and maturity rate of females were also high for southern (69.8%) strata (only two immature females were sampled in the northern strata). Apparent pregnancy rate of sampled animals was high (94.0%) and five simultaneously lactating and pregnant animals were observed in this survey.

Body length distribution

Summary of body length statistics and length distribution by sex and stratum are shown in Table 3 and Figure 4. The range of body length of sampled whales were 5.07m to 9.18m for males and 5.35m to 9.74m for females. Various size of animals ranging from 5m to 9m were sampled in all strata.

Stomach contents

Table 4 shows the frequency of dominant prey species found in the forestomach, by stratum. Antarctic krill (*Euphausia superba*) was the dominant prey species in the research area. *Thysanoessa*. *sp*. was found in six animals.

Other sampling

Summary of biological data and samples collected from each whale was shown in Table 5. During the survey, earplugs were collected from all animals. Eye lenses were also collected from all animals for the purpose of age determination based on the ratio of aspartic acid enantiomers in the lens nucleus. Other samples such as baleen plate, prey species from stomach contents, blood, muscle, and internal organs would be used to achieve objectives of NEWREP-A.

Data and samples obtained from this survey will be validated and stored at the Institute of Cetacean Research (ICR), Japan, and they are available to national (Japan) and international scientists under established guidelines (see http://www.icrwhale.org/NEWREP-AProtocol.html).

First sighting and sampling survey in Area III-West

Sighting and sampling survey in Area III-West was conducted for the first time since the start of JARPA in 1987/88. The survey was conducted in the early season (late December to early February). Antarctic minke whales were widely distributed from offshore to the sea ice area, although the density high at the southern stratum (Figure 3). Mature individuals of both sexes dominated in the south strata (Table 2 and Figure 4). The obtained samples will contribute to elucidation of the stock structure of Antarctic minke whales, especially to elucidation of the western boundary of the I-stock.

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Table 1.

Outline of the 2018/19 NEWREP-A sighting and sampling survey.

Event	Date
Departure from Japan	12 Nov. 2018
Low and middle latitudinal sighting survey	25 Nov. 2018 - 11 Dec. 2018
Whale sampling survey (III-West)	18 Dec. 2018 - 2 Feb. 2019
Whale sampling survey (III-East)	3 Feb. 2019 - 27 Feb. 2019
Low and middle latitudinal sighting survey	1 Mar. 2019 - 12 Mar. 2019
Arrival in Japan	31 Mar. 2019

Table 2.

Sex and reproductive status of Antarctic minke whales sampled in each stratum.

Area	Stratum	Male			Female							Total
						Mat.						
		Imm.	Mat.	Total	Imm.	Ovu.	Rest.	Preg.	Preg. & Lact	Total	Total	
III-West	North	19	48	67	18	0	0	6	1	7	25	92
	South	14	62	76	31	0	2	41	3	46	77	153
III-East	North	5	6	11	2	0	0	0	0	0	2	13
	South	7	25	32	13	1	2	26	1	30	43	75
Combined		45	141	186	64	1	4	73	5	83	147	333

Table 3.

Body length statistics of Antarctic minke whales collected during the 2018/19 NEWREP-A survey.

Area	Stratum	Male					Female				
		n	mean	S.D.	min	max	n	mean	S.D.	min	max
III-West	North	67	7.92	0.98	5.07	9.05	25	7.40	1.04	5.35	9.05
	South	76	8.15	0.62	5.62	9.18	77	8.10	1.19	5.51	9.74
III-East	North	11	7.30	1.06	5.64	9.14	2	6.19	0.53	5.65	6.72
	South	32	8.08	0.91	5.14	9.08	43	8.40	0.92	6.07	9.53
Combined		186	8.00	0.87	5.07	9.18	147	8.04	1.15	5.35	9.74

Table 4.

Main prey species found in the stomach of Antarctic minke whales.

Strataum	Prey species		Empty	Broken*	Total
	Euphausia superba	*Thysanoessa spp.*			
West North	48	4	37	3	92
West-South	75	1	73	4	153
East-North	9	1	2	1	13
East-South	41	0	31	3	75
Combined	173	6	143	11	333

*Broken: animals with broken stomach by harpoon.

Table 5.

Summary of data and samples collected during the 2018/19 NEWREP-A survey.

	Items	Male	Female	Total
Data	Catch date and location	186	147	333
	Photographic record of external character	186	147	333
	Record of internal and external parasites	186	147	333
	Sex and body length	186	147	333
	Body proportion for stock structure	186	147	333
	Skull measurements (length and breadth) for stock structure	181	144	325
	Body weight for feeding ecology	186	147	333
	Organ weight for feeding ecology	3	2	5
	Total fat weight for feeding ecology	31	24	56
	Diatom film record for feeding ecology	186	147	333
	Blubber thickness for feeding ecology	186	147	333
	Weight of stomach content for feeding ecology	183	145	328
	Testis weight for reproductive study	186	-	186
	Mammary gland: lactation status and measurement for reproductive study	-	147	147
	Foetal number, sex, length and weight for reproductive study	34	36	77*
	Observation of marine debris (stomach)	186	147	333
	Gross pathological observation and sampling	186	147	333
Samples	Prey species in stomach for feeding ecology	26	22	48
	Testis for reproductive study	186	-	186
	Ovary for corpora counting and reproductive study	-	147	147
	Mammary grand for reproductive study	-	147	147
	Earplug for age determination	186	147	333
	Ocular lens for age determination	186	147	333
	Baleen plates for age determination	25	39	64
	Tissue samples for genetic study	186	147	333
	Tissue and organ samples for chemical study	186	147	333
	Plasma samples for physiological study	134	108	242
	Vertebral epiphyses for growth study	161	108	269

* Including seven fetus of sex undetermined.

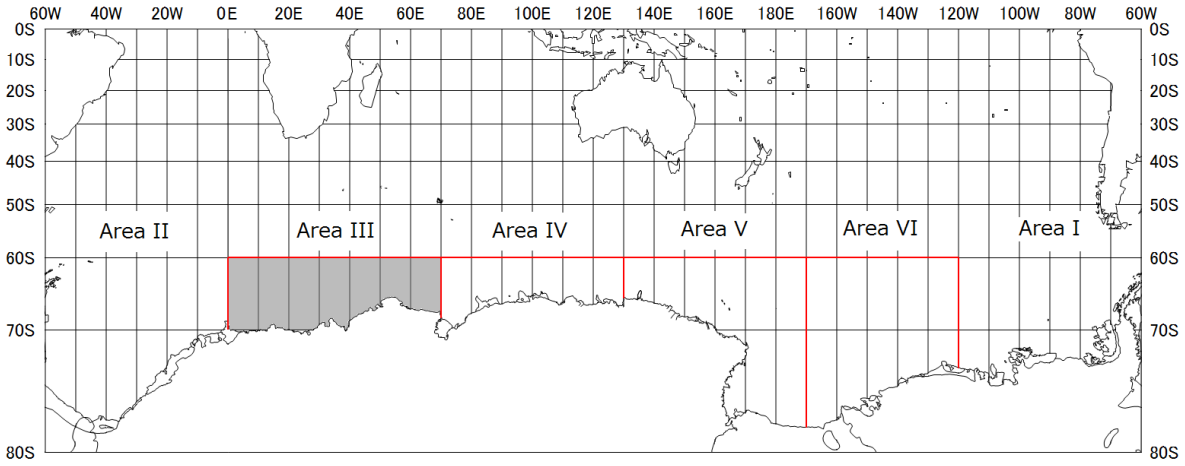

Figure. 1. Research area of the 2018/19 NEWREP-A sighting and sampling survey.

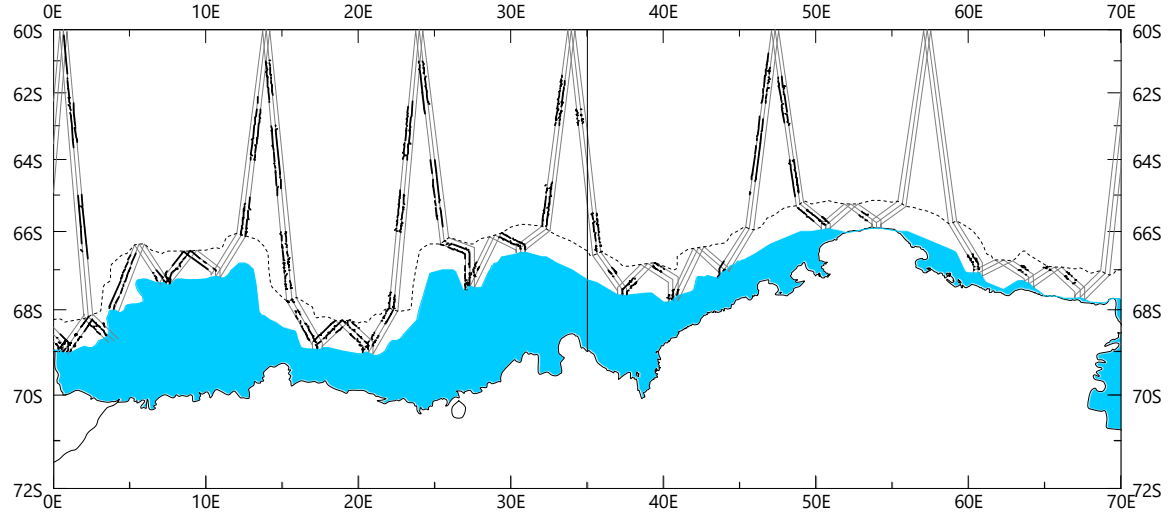

Figure 2. Pre-determined (gray) and actually covered (bold black) track lines made by two SSVs. The light blue area shows sea-ice distribution.

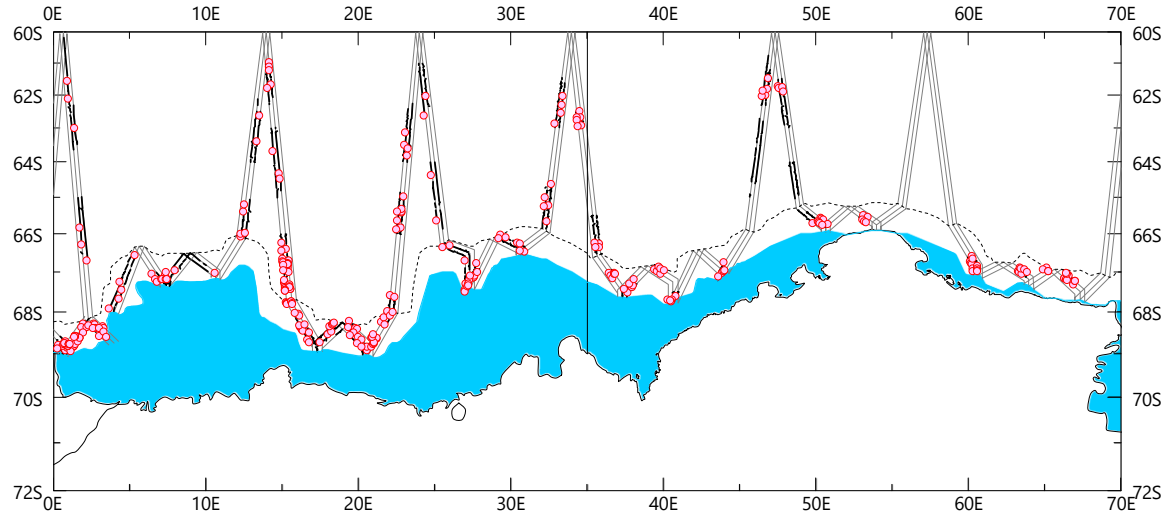

Figure 3. Sighting positions of sampled Antarctic minke whales.

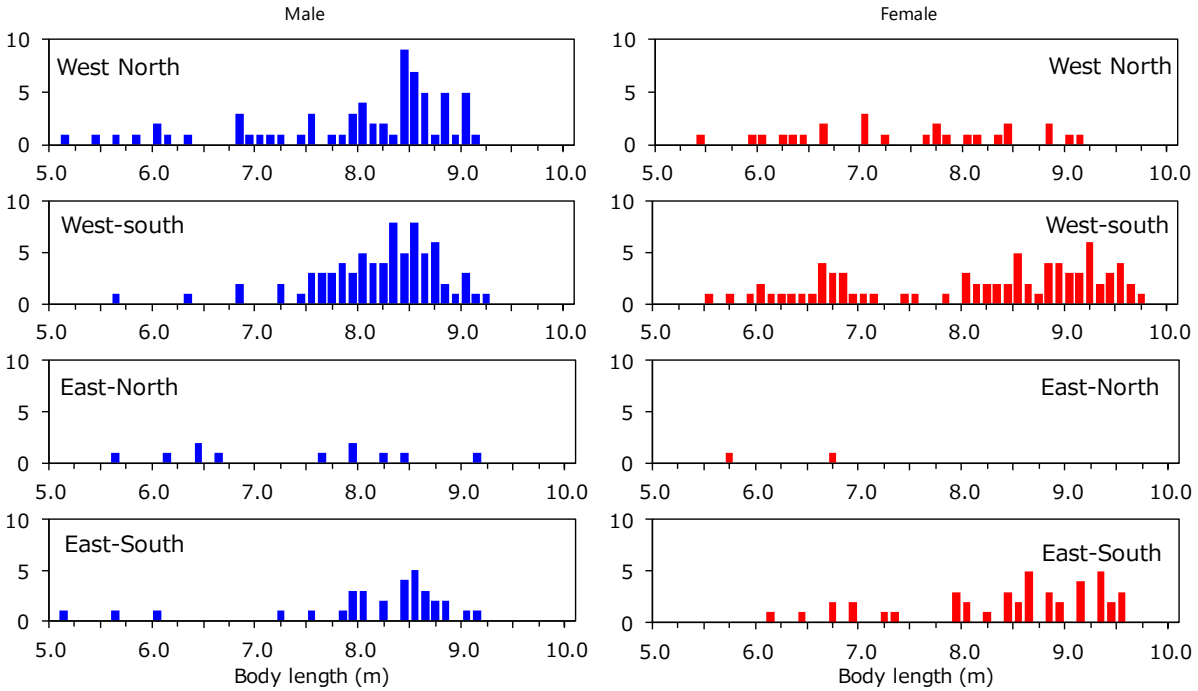

Figure 4. Body length distribution of Antarctic minke whales sampled in each stratum.

APPENDIX

Sighting results by the sighting and sampling vessels during the 2018/19 NEWREP-A survey in Area III (0°-70°E)

IDENTIFICATION OF SPECIES

Guidelines for species identification were based on the IWC-SOWER methods for classification of identification (IWC, 2008): 'Positive identification of species was based on multiple cues and usually required clear observation of the whale's body. Occasionally, repeated observations of the shape of the blow, surfacing, and other behavioural patterns were sufficient; this judgement was made only by the Cruise leader or other designated researcher. Identification of species was recorded as 'probable' based on multiple cues, which were nevertheless insufficient to be absolutely confident of identification. This usually occurred when blows and surfacing patterns could be confirmed, but the whale's body could not be clearly seen. Details of recording procedures during sightings can be found in 'Information for Researchers''. From initial observations of morphologic characteristics, killer whale (*Orcinus orca*) data were divided into three ecotypes (Pitman and Ensor, 2003).

DETERMINATION OF GROUP SIZE

The following guidelines were used in determining group size (IWC, 2008): 'Schools where the number of animals or an accurately estimated range of the number of animals was determined, were classified as confirmed schools. Data from the confirmed schools can be used to determine a mean school size. Therefore, it is critical that the confirmed schools accurately represent the size of schools in the survey area. Normally, schools believed to be confirmed for school size are approached to within 1 n. mile for large whales and to within 0.3 n. miles for Antarctic minke whales (*Balaenoptera bonaerensis*). Allowing for context-specific differences (i.e. environmental conditions and animal behaviour), every effort was made to be consistent with regard to the maximum time spent on the identification of species and confirmation of numbers. Normally, if the sighting was thought to be Antarctic minke whales, no more than 20 minutes (after the closure has been completed) should be spent on confirmation. This reduces the potential for confusion with other sightings in the vicinity. Counts of individuals provided by the sighting summary represent best estimates of school sizes in the research area, except when indicated otherwise.

OTHER RESEARCH ACTIVITIES

Photo-ID

Photo-ID data of individual whales was collected for stock structure analyses as well as examining mixing and movements during the research period. Data were captured by digital photograph using Digital camera (300mm lens, Canon Co., Ltd., Japan). Target species for Photo-ID were blue whale (*B. musculus*), humpback whale (*Megaptera novaeangliae*), southern right whale (*Eubalaena australis*), and killer whales.

Biopsy sampling for large whales

Samples of skin biopsy were collected by biopsy from the target whales. The target species were blue whale, fin whale (*B. physalus*), sei whale (*B. borealis*), southern right whale, sperm whale (*Physeter macrocehpalus*), killer whale, pygmy right whale (*Caperea marginata*), and southern bottlenose whale (*Hyperoodon planifrons*) sighted in the research time. The system for biopsy sampling was a Larsen system (Larsen, 1998). The open sight was replaced with an electronic aiming device (red-dot-sight), which allows faster aiming and thus faster shooting. The biopsy darts consisted of a carbon fibre shaft, which is high-pressure moulded to a polyethylene float that also functions as a stop to limit penetration into the tissue. In the float end of the dart, a threaded insert is used for attaching the screw-on biopsy-sampling tip. The biopsy tip is a stainless steel cylinder with a 9mm outer diameter, an internal diameter of 7mm and three internal barbs for sample retention. All collected samples were stored at −20°C.

RESULT

Sightings

The searching effort is summarised in Table 1. The WP of the SSV's track-line of sighting and sampling survey is shown in Table 2. Total searching distance in the research area was 3,907 n.miles (main and sub course). The

sighting records are not suitable for design-based abundance estimation as the sighting records of the sampling and survey vessels were made by NSC mode using TOP and UBP except for examination of the distribution of specified species using model-based estimation. The sightings recorded in the sighting and sampling survey are shown in Table 3. Figures 1and 2 show the geographical distribution of large whales sighted in survey. In Area III, humpback whales were the most abundant species followed by Antarctic minke and fin whales (Table 3).

Antarctic minke whale were found in a wide area from the ice edge to offshore in the Area III with a high density area in the ice edge area (Figure 1). Humpback whales were also found in wide area in northern and southern stratum. Fin whales were mainly found in the northern strata (Figure 2).

Effort was made to identify killer whales into three ecotypes (types A, B and C) based on differences of morphological characteristics. A total of 5 schools (36 individuals) were sighted. No school was identified to an ecotype due to the difficulty of approaching the whales.

Photo ID and biopsy

Photo-ID data was obtained from eight southern right whales during transit to the research area. Photo-ID was also obtained from 36 humpback whales in the research area.

In terms of biopsy skin sampling, eight sample was collected from southern right whales during transit to research area and 29 humpback, two fin and one Antarctic minke whales in the research area. The number of Photo-ID and biopsy samples are summarised in Table 4. The records will provide useful data for understanding the stock structure, mixing and movements of these species. These data will be submitted to the IWC secretary and will be analysed by comparing previous IWC and other relevant catalogues (e.g. Olson, 2012, Matsuoka and Pastene, 2009). Biopsy samples obtained during surveys of the NEWREP-A 2018/19 will be used for microsatellite DNA loci analysis for studies of stock structure in the Antarctic feeding ground. Biopsy samples may also be used for other research (e.g. chemical markers as body condition indicator, stable isotope, or hormones).

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Table 1

Summary of research effort (n. miles) conducted by the two SSVs during the 2018/19 NEWREP-A survey. *NSC* mode represents sighting and sampling survey and *ASP* mode represents sighting survey. *BC* and *BI* means survey under normal and sea ice condition, respectively.

Area	Stratum	Survey mode				Total
		NSC		*ASP*		
		BC	*BI*	*BC*	*BI*	
III-West	North	1,939.7	102.2	0.0	0.0	2,042.0
	South	776.3	188.4	0.0	0.0	964.7
III-East	North	657.7	0.0	0.0	0.0	657.7
	South	210.6	26.8	4.1	1.1	242.7
Combined		3,584.2	317.5	4.1	1.1	3,907.0

Table 2

Predetermined waypoints (WP) and the actually covered (main course) ratio of sighting and sampling survey.

Stratum	WP	Latitude			Longitude			Leg No.	Distance	Effort	Covered (%)
West-North	401	63	31	S	0	0	E	401	211.8	0.0	0.0
	402	60	0	S	0	39	E	402	491.9	266.4	54.2
	403	68	10	S	2	19	E	-	-	-	-
	409	66	5	S	12	19	E	409	367.8	141.7	38.5
	410	60	0	S	13	59	E	410	467.1	182.0	39.0
	411	67	45	S	15	39	E	-	-	-	-
	415	68	0	S	22	19	E	415	482.0	158.0	32.8
	416	60	0	S	23	59	E	416	377.7	164.5	43.5
	417	66	15	S	25	39	E	-	-	-	-
	421	65	55	S	32	19	E	421	357.9	127.6	35.7
	422	60	0	S	33	59	E	422	253.3	10.3	4.1
	Total								3009.4	1050.4	34.9
East-North	423	64	12	S	35	0	E	423	144.2	49.6	34.4
	424	66	35	S	35	39	E	-	-	-	-
	430	65	55	S	45	39	E	430	357.9	144.6	40.4
	431	60	0	S	47	19	E	431	318.3	133.5	42.0
	432	65	15	S	48	59	E	-	-	-	-
	436	65	15	S	55	39	E	436	318.3	0.0	0.0
	437	60	0	S	57	19	E	437	348.0	0.0	0.0
	438	65	45	S	58	59	E	-	-	-	-
	444	67	5	S	68	59	E	444	247.8	0.0	0.0
	445	62	59	S	70	0	E	-	-	-	-
	Total								1734.6	327.8	18.9

Table 2

Continued.

Stratum	WP	Latitude			Longitude			Leg No.	Distance	Effort	Covered (%)
West-South	301	68	36	S	0	0	E	301	31.9	5.7	17.8
	302'	68	50	S	0	39	E	-	-	-	-
	302	69	2	S	0	39	E	302	63.5	33.1	52.1
	303	68	10	S	2	19	E	303	50.7	10.8	21.4
	304'	68	45	S	3	59	E	-	-	-	-
	304	68	0	S	3	59	E	304	107.3	67.8	63.2
	305	66	20	S	5	39	E	305	71.8	19.8	27.5
	306'	67	20	S	7	19	E	-	-	-	-
	306	67	20	S	7	19	E	306	63.6	52.0	81.8
	307	66	30	S	8	59	E	307	59.6	29.3	49.2
	308'	67	0	S	10	39	E	-	-	-	-
	308	67	10	S	10	39	E	308	76.2	0.0	0.0
	309	66	5	S	12	19	E	-	-	-	-
	311	67	45	S	15	39	E	311	81.8	39.6	48.4
	312'	68	50	S	17	19	E	-	-	-	-
	312	68	57	S	17	19	E	312	55.7	39.0	70.0
	313	68	15	S	18	59	E	313	62.7	31.2	49.8
	314'	68	50	S	20	39	E	-	-	-	-
	314	69	2	S	20	39	E	314	72.0	30.8	42.7
	315	68	0	S	22	19	E	-	-	-	-
	317	66	15	S	25	39	E	317	97.8	64.0	65.4
	318'	66	30	S	27	19	E	-	-	-	-
	318	67	25	S	27	19	E	318	89.2	9.5	10.6
	319	66	5	S	28	59	E	319	53.0	33.5	63.1
	320'	66	25	S	30	39	E	-	-	-	-
	320	66	33	S	30	39	E	320	55.4	0.0	0.0
	321	65	55	S	32	19	E	-	-	-	-
	Total								1092.2	466.0	42.7
East-South	324	66	35	S	35	39	E	324	75.4	11.8	15.6
	325'	67	30	S	37	19	E	-	-	-	-
	325	67	38	S	37	19	E	325	61.7	18.7	30.4
	326	66	50	S	38	59	E	326	76.4	22.4	29.4
	327'	67	15	S	40	39	E	-	-	-	-
	327	67	45	S	40	39	E	327	89.0	0.1	0.1
	328	66	25	S	42	19	E	328	54.8	2.7	5.0
	329'	67	0	S	43	59	E	-	-	-	-
	329	67	2	S	43	59	E	329	78.0	1.4	1.8
	330	65	55	S	45	39	E	-	-	-	-
	332	65	15	S	48	59	E	332	60.2	28.2	46.7
	333'	65	50	S	50	39	E	-	-	-	-
	333	65	56	S	50	39	E	333	58.2	0.0	0.0
	334	65	15	S	52	19	E	334	60.2	8.3	13.7
	335'	65	45	S	53	59	E	-	-	-	-
	335	65	54	S	53	59	E	335	56.9	0.0	0.0
	336	65	15	S	55	39	E	-	-	-	-
	338	65	45	S	58	59	E	338	91.5	12.7	13.8
	339'	66	50	S	60	39	E	-	-	-	-
	339	67	5	S	60	39	E	339	44.0	0.0	0.0
	340	66	45	S	62	19	E	340	57.5	0.9	1.5
	341'	67	10	S	63	59	E	-	-	-	-
	341	67	21	S	63	59	E	341	46.8	0.2	0.5
	342	66	55	S	65	39	E	342	64.2	1.6	2.5
	343'	67	30	S	67	19	E	-	-	-	-
	343	67	42	S	67	19	E	343	53.381815	0	0
	344	67	5	S	68	59	E	-	-	-	-
	Total								1028.3	108.9	10.6

Table 3

Species and number of whales sighted in the Area III (0°-70°E) by the two SSVs during the 2018/19 NEWREP-A survey.

	Stratum (Area III)																					
	West-North				West-South				East-North				East-South				Total					
	Primary		Secondary		Primary		Secondary		Primary		Secondary		Primary		Secondary		Primary		Secondary		Total	
Species	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.
Blue whale	1	1	0	0	6	7	3	3	0	0	1	1	0	0	0	0	7	8	4	4	11	12
Fin whale	38	82	0	0	7	8	0	0	21	47	1	2	5	13	0	0	71	150	1	2	72	152
Antarctic minke whale	97	140	0	0	169	285	0	0	16	19	0	0	80	158	0	0	362	602	0	0	362	602
Like Antarctic minke	4	4	0	0	4	4	0	0	2	2	0	0	1	1	0	0	11	11	0	0	11	11
Humpback whale	183	262	0	0	73	113	2	3	95	172	0	0	48	70	0	0	399	617	2	3	401	620
Baleen whale	13	13	0	0	4	6	0	0	3	5	0	0	2	2	0	0	22	26	0	0	22	26
Sperm whale	12	12	0	0	0	0	0	0	2	2	0	0	0	0	0	0	14	14	0	0	14	14
Southern bottlenose whale	4	8	0	0	2	4	0	0	2	6	0	0	1	1	0	0	9	19	0	0	9	19
Killer whale (undetermined)	1	8	0	0	1	8	0	0	1	3	0	0	2	17	0	0	5	36	0	0	5	36

Table 4

Summary of biopsy and photo-ID experiment conducted by the SSVs.

Species	Biopsy	Photo-ID
Southern right whale	8	8
Humpback whale	29	36
Fin whale	2	0
Antarctic minke whale	1	0

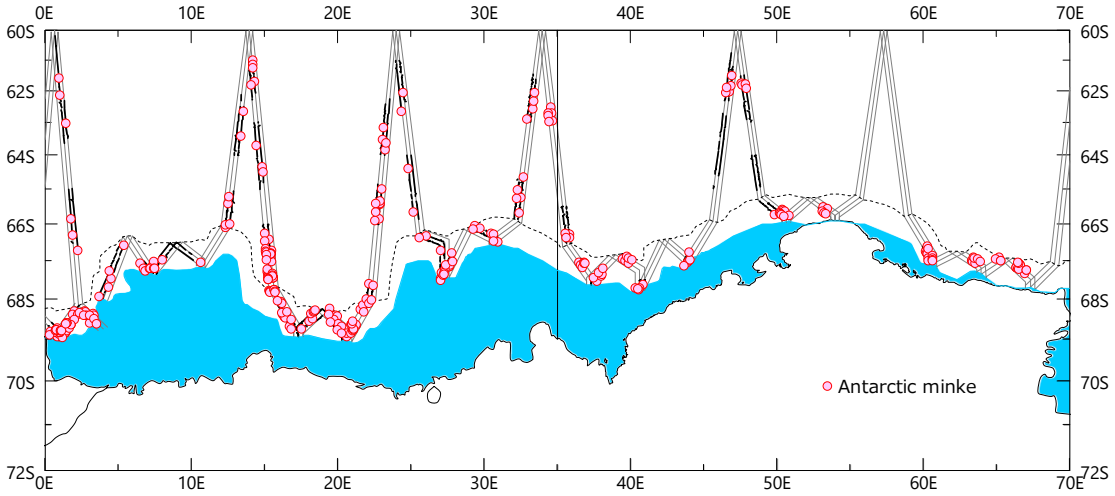

Figure 1. Geographical distribution of primary sightings of Antarctic minke whales sighted in the 2018/19 NEWREP-A sighting and sampling survey. The gray line shows pre-determined track-lines and black bold line shows on-effort lines. The light blue area shows sea-ice distribution.

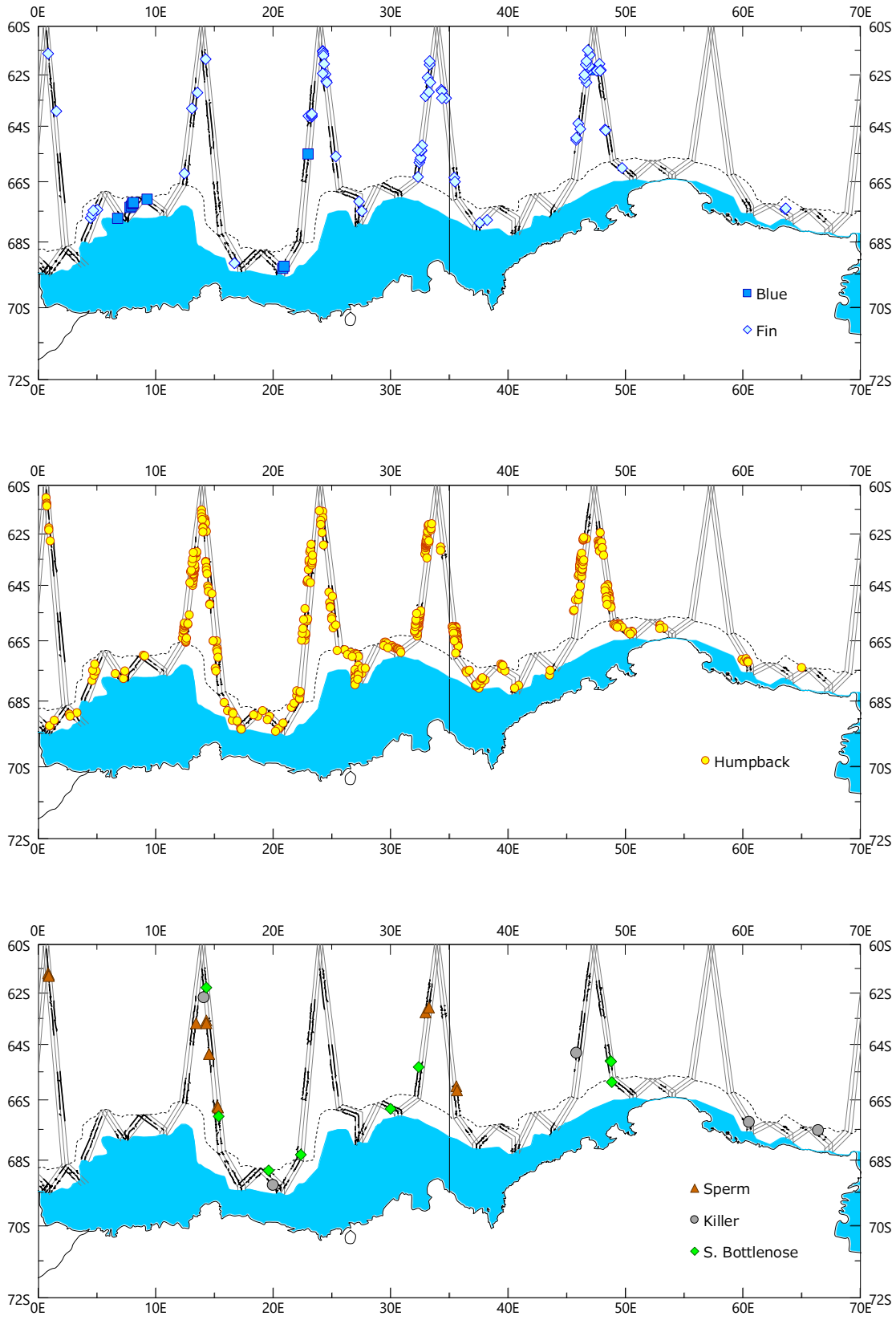

Figure 2. Geographical distribution of primary sightings of blue, fin (upper), humpback (middle) and sperm, killer, southern bottlenose (lower) whales sighted in the 2018/19 NEWREP-A sighting and sampling survey. The gray line shows pre-determined track-lines and black bold line shows on-effort lines. The light blue area shows sea-ice distribution.