Abundance of J-stock common minke whales in the Sea of Japan using the Japanese sighting data with g(0)=1

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ABSTRACT

Using the Japanese sighting data obtained by three research vessels in the Sea of Japan from 2002 to 2007, abundance of J-stock common minke whales in the research areas was estimated assuming g(0)=1. The conventional line transect method considering the covariates such as ‘year’, ‘area’, ‘vessel’ and ‘wind’ (sea state) was applied. Hazard-rate and half-normal model were considered as detection function and the former was selected by AIC with significant covariates, ‘wind’, ‘area’ and ‘year’. School size was estimated from the combined data of all vessels because the almost schools were composed of singleton but size bias was corrected by regression method. Four blocks (10W, 10E, 6EN and 6ES) were set based on vessel and year coverage. 10W was covered by *Kaiko-maru*, 10E and 6EN were covered by *Shonan-maru No.2* and 6ES by *Kurosaki*. The northernmost block 10W (Russian EEZ) was covered in 2006 and the abundance was estimated as 2,855(CV=0.327). Block 10E (east of Hokkaido) was surveyed in 2002, 2003, 2004, 2005 and 2007, and abundances estimates were 816 (CV=0.658), 405 (CV=0.566), 474 (CV=0.537), 666 (0.444) and 575 (CV=0.327), respectively. Abundance in block 6EN was estimated as 891 (CV=0.608) in 2002, 935 (CV=0.357) in 2003 and 727 (CV=0.372) in 2004. The southernmost block 6ES was covered in 2002 and 2003, the abundances were estimated as 905 (CV=0.684) and 124 (CV=0.582), respectively.

KEY WORD: COMMON MINKE WHALE, ABUNDANCE ESTIMATE, SIGHTING SURVEY, SEA OF JAPAN

INTRODUCTION

Japan has conducted a series of sighting surveys in the East China Sea, Yellow Sea and the Sea of Japan where is main habitat of the J-stock of common minke whales under the cooperative project between Japan and Korea since 1994 (Iwasaki *et al*., 1995, 2000; Miyashita, 2001, 2002, 2004, 2005, 2007 ; Miyashita and Yoshida, 2003). Miyashita (2005b) presented the abundance estimates in the Japanese side of sub-areas 6 and 10 using 2002 and 2003 data. Miyashita and Okamura (2007) presented the abundance estimates in the Russian EEZ in sub-area 10 using 2006 data. The 59th SC agreed to get the integrated abundance estimate for J-stock common minke whales using the Japanese and the Korean sighting data in the research area assuming g(0)=1 and the works has been still continued. This document presented the abundance estimates from the Japanese data for integrated abundance estimate by Kitakado et al. (2009)

MATERIALS AND METHOD

Sub-areas 6 and 10 were set in the Sea of Japan for Implementation Simulation Trials for North Pacific common minke whales (Fig. 1). In this study, the Japanese side of the sub-area 6 was divided into two blocks, 6ES and 6EN (Fig. 2). In the sub-area 10, the EEZ line between Japan and Russia was set to be the border line between two blocks, 10E (Japanese side) and 10W (Russian side) (Fig. 2).

The season of surveys in the waters was set from April to June when the Japanese small-type coastal whaling mainly caught the minke whales in this area. In 2002 and 2003, *Kurosaki* (KSK) covered block 6ES from mid-April to mid-May, and *Shonan-maru No.2* (SM2) covered 6EN and 10E from mid-May to late-June (Table 2). In

2004, SM2 covered in block 6EN and 10E from mid-May to late-June. In 2005, we tried to enter the Russian EEZ (10W) first time, but no permission was issued from Russia. Then SM2 has covered twice 10E and accumulated the sighing information from mid-May to late-June (Table 2). And in 2006, we got the Russian permission to enter the EEZ (10W) and *Kaiko-maru* (KKM) covered there from late-May to mid-June (Table 2). In 2007, SM2 conducted the IO passing mode survey north of Hokkaido (10E and sub-area 11 in the Sea of Okhotsk) and 10E was covered in June (Table 2). The track line traversed with sighting effort and the sighting positions of common minke whale school were shown in Figs 3 to 8 from 2002 to 2007, respectively.

In this study, all sighting data from late April to June in 2002 to 2007 were used for the estimation (Table 1). All vessels have a top-barrel and are suitable for whale observation. KKM and SM2 have also an IO platform. Two top men were primary observers and scientists on the upper bridge conducted the record of sighting. The sighting method was followed the Guideline for sighting survey under RMP and the survey design was presented to the past SC and Miyashita was appointed to have oversight. Based on the distance and angle estimation experiments, if the correction is necessary, the angle and distance was corrected.

The surveys were conducted under the weather when the visibility better than 2 n.miles and the wind force less than four. The survey mode in the research area was normal closing mode from 2002 to 2005 and IO passing mode in 2006 and 2007. In order to remove outliers and improve the fitness of detection function, perpendicular distance data were truncated at 1.5 nmi. This resulted in the exclusion of 1.6% of all observations. For KKM, it was necessary to correct the distance and angle data. The detection probability was estimated using Multiple Covariate Distance Sampling (MCDS) (Buckland *et al*., 2004). Covariates to be taken into account were 'year', 'area', 'vessel' and 'wind'(sea state). Block-specific estimates of density and abundance was conducted by the program using R developed by Okamura because the program *DISTANCE* Version 5.1 (Thomas *et al*., 2006) covering MCDS but did not make a reliable result under the Windows for two byte language such as Japanese. Therefore performance of the Okamura's program was certified in the case of no covariates by comparing the result with the program *DISTANCE* Version 4.1 (Thomas *et al*., 2003). Hazard rate probability curve and half normal curve were candidates as the key function of detection curve in this study. The model and covariates used to estimate abundances was selected by AIC. The probability to detect common minke whales on the track line was assumed as g(0)=1.

Because 89% of schools were composed of singleton and no clear differences in distribution between areas, mean school size was estimated from all the data combined. Size bias was corrected by the regression method (Buckland *et al*., 1993).

RESULTS AND DISCUSSION

Information on model selection and covariates used to estimate abundances are listed in Table 3. The model selected for key function was hazard-rate model and significant covariates were 'wind', 'area' and 'year'. Fitness of the detection curve to the observed values is shown in Fig. 9.

The estimates of abundance by block and year are shown in Table 4. In 10E, the estimates have a wide range from 405 in 2003 to 816 in 2002. About the small number in 2003, it has already pointed out that the surface water temperature in 2003 was colder (about 2^{o}C) than in 2002 in the area and effected to the habitat of common minke whales (Miyashita, 2005b). The estimates in block 6EN were almost constant through three years (2002-2004). In 10W, many minke whales were sighted there especially between the Sakhalin Island and the continent (Fig. 7) and those has been already suggested form the distribution pattern in the offshore part in 10E (Miyashita, 2005b). The abundance in 10W is estimated as 2,855 (CV=0.327) which was not different from the past result 2,891 (CV=0.324) (Miyashita and Okamura, 2008). In 6ES, two estimates have much different and large CV. Considering small sighting effort in the offshore sub-block in 2002 caused by bad weather (Fig. 3), it seems that abundance estimate in 2002 has low reliability.

The survey area in these surveys covered partially in both sub-areas, about 50% for sub-area 6 and 77% for sub-area 10. Korean survey in the sub-area 6 is very useful to get more coverage, but the North Korean waters in the sub-areas 6 and 10 are still remained as un-surveyed area. Former abundance estimates in the sub-areas 6 and 10 used in the conditioning of IST for the Okhotsk Sea - western North Pacific stock were based on the sighting surveys in August and September (Miyashita and Shimada, 1994). Those were 891 in the sub-area 6 and 707 in the sub-area 10 and used as minimum estimate because of existence of un-surveyed area in the continental side and assuming of g(0)=1. The present results can partially dissolve this under estimate of abundance but g(0) estimate from the IO mode surveys should be used for correction (Okamura *et al.,* 2009).

The Sea of Japan has been considered as migration corridor of the species, but no direct information on the timing of northward and southward migration such as tagging data (Discovery tag or satellite tracking). But there is some related information from other field. In April, it is known that J-stock animals have already migrated into the Sea of Okhotsk (sub-area 11) (Kanda *et al.* 2009). Then the northward migration occurs or started before April. On the other hand, the conception timing of J-stock animals is considered in autumn (Kato, 1992) and mother-calf pairs have been observed in the northern Sea of Japan during the past sighting surveys (Miyashita, 2004; 2005a; 2006). Those suggest the peak of the northward migration finishes in April to June, and the animals in the Sea of Japan stay there during this period. On the other hand, no concrete information has also obtained for the timing of the southward migration, but it starts after the peak of the northward migration namely in July or August, and J-stock animals move to breeding ground in the lower latitudinal area. Taking into account of such information, the timing of sighting surveys from April to June can be treated as single period, and the abundance from this timing can be added together without large double-counting risk. However, it is necessary to confirm the migration pattern by the direct information in the future.

REFERENCES

Buckland, S.T., Anderson, D.R., Burnham, K.P. and Laake, J.L. 1993. *Distance Sampling: Estimating Abundance of Biological Populations*, Chapman and Hall, London. 446pp.

Buckland, S.T., Anderson, D.R., Burnham, K.P., Laake, J.L, Borchers, D.L. and Thomas, L. 2001. *Introduction to Distance Sampling: Estimating Abundance of Biological Populations.* Oxford University Press, New York. 432pp.

Buckland, S.T., Anderson, D.R., Burnham, K.P., Laake, J.L, Borchers, D.L. and Thomas, L. 2004. *Advanced Distance Sampling: Estimating abundance of biological populations.* Oxford University Press, New York. 416pp.

Iwasaki, T., Hwang, H. and Nishiwaki, S. 1995. Report of whale sighting surveys in waters off Korean Peninsula and adjacent waters in 1994. Document SC/47/NP18 presented to the IWC/SC,15pp.

Iwasaki, T., Shimada, H., Kim S.T. 2000. Cruise report of Japanese pilot sighting survey conducted under the joint research program between Japan and Republic of Korea in 1999 summer. Document SC/52/RMP11 presented to the IWC/SC. 9pp.

Kanda, N., Goto, M. and Pastene, L.A. Update of the microsatellite analysis of common minke whales from Japanese waters. Document SC/61/NPM8. 9pp.

Kato, H. 1992. Body length, reproduction and stock separation of minke whales off northern Japan. Rep. int. Whal. Commn 42:443-453.

Kitakado, T., An, Yong-Rock, Choi, Seok-Gwan, Miyashita, T., Okamura, H and Park, Kyum-Joon. 2009. **I**ntegration of abundance estimates for common minke whales in sub-areas 5, 6 and 10 using sighting data from Japanese and Korean surveys. Document SC/61/NPM6. 9pp.

Integrated abundance estimates of J-stock common minke whales in sub-areas 5, 6 and 10 using sighting data from Korean and Japanese surveys. Document SC/61/NPM6.

Miyashita, T. 2001.Cruise report of the Japanese sighting survey under the joint research program, between Japan and Korea in 2000 and 2001. Document SC/53/RMP6 presented to the IWC/SC. 6pp.

Miyashita, T. 2002. Cruise report of the Japanese sighting survey under the joint research program between Japan and Korea in 2000 and 2001. Document SC/53/RMP6. 5pp

Miyashita, T. 2004a. Cruise report of the Japanese sighting survey under the Japan/Korea joint project in 2003. Document SC/56/RMP2. 8pp.

Miyashita, T. 2004b. Cruise report of the common minke whale sighting surveys in the Sea of Okhotsk in 2003. Document SC/56/RMP1. 10pp.

Miyashita, T. and Shimada, H., 1994. Minke whale abundance in the Okhotsk, Sea of Japan and off the Pacific coast of Northern Japan estimated from sighting data. Document SC/46/NP6. 9pp.

Miyashita, T. and Yoshida, H. 2003. Report of the Japanese sighting survey the Japan/Korea joint project in 2002. SC/55/RMP5. 7pp.

Miyashita, T. 2004. Report of the Japanese sighting survey under Japan/Korea joint poject in 2003. Document SC/56/NPM2. 8pp.

Miyashita, T. 2005a. Cruise report of minke whale sighting survey in the Sea of Japan in 2004. Document SC/57/NPM1. 5pp.

Miyashita, T. 2005b. Abundance estimate of J-stock minke whales using the Japanese sighting data. Document SC/57/NPM3. 6pp.

Miyashita, T. 2007. Cruise report of the IO sighting survey in the northern Sea of Japan in 2006. SC/59/NPM3. 8pp.

Miyashita, T. and Okamura, H. 2007. Abundance estimate of common minke whales in the northern Sea of Japan including the Russian EEZ using IO sighting data in 2006. Document SC/59/NPM4. 10pp.

Miyashita, T. 2008. Cruise report of the IO sighting survey in the Sea of Japan and the Sea of Okhotsk off the northern Hokkaido in 2007. Document SC/60/NPM4. 7pp.

Okamura, H. and Miyashita, T. and Kitakado, T. 2009. Revised estimate of g(0) for J-stock common minke whales. Document SC/61/NPM5.

Thomas, L., Laake, J.L., Strindberg, S., Marques, F.F.C., Buckland, S.T., Borchers, D.L., Anderson, D.R., Burnham, K.P., Hedley, S.L., Pollard, J.H. and Bishop, J.R.B. 2003. Distance 4.1. Release 2. Research Unit for Wildlife Population Assessment, University of St. Andrews, UK. http://www.ruwpa.stand.ac.uk/distance/

Thomas, L., Laake, J.L., Strindberg, S., Marques, F.F.C., Buckland, S.T., Borchers, D.L., Anderson, D.R., Burnham, K.P., Hedley, S.L., Pollard, J.H., Bishop, J.R.B. and Marques, T.A. 2006. Distance 5.0. Release 2. Research Unit for Wildlife Population Assessment, University of St. Andrews, UK. http://www.ruwpa.st-and.ac.uk/distance/

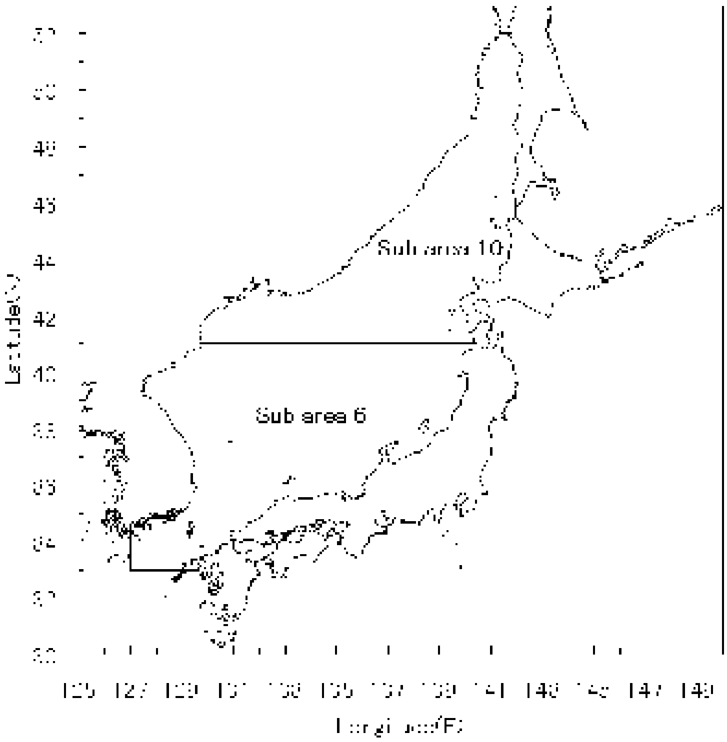

Fig. 1. Definition of sub-area 6 and 10 for the Implementation Simulation Trials for North Pacific minke whales.

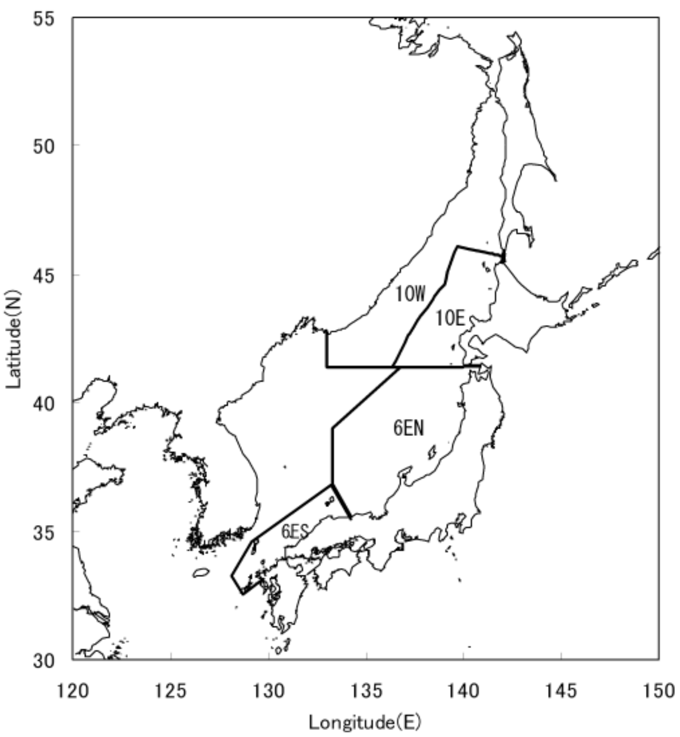

Fig2. Definition of blocks for this study.

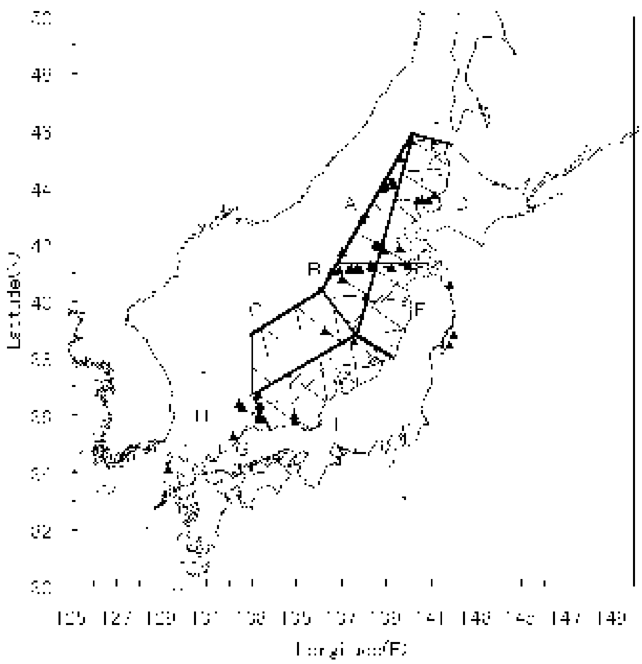

Fig. 3. Track line traversed with sighting effort and sighting positions of common minke whale schools in 2002. Thick line: block, thin line : track line, triangle : sighting position.

Sub blocks A-F were covered by *Shonan-maru No.2*, and H-G by *Kurosaki*.

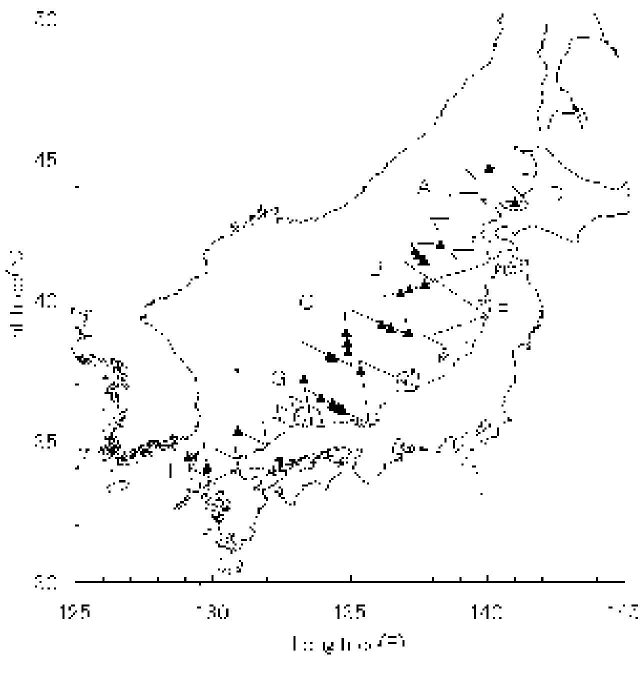

Fig. 4. Track line traversed with sighting effort and sighting positions of common minke whale schools in 2003. Thick line: block, thin line : track line, black triangle : sighting position.

Sub-blocks A-F were covered by *Shonan-maru No.2*, and G-I by *Kurosaki*.

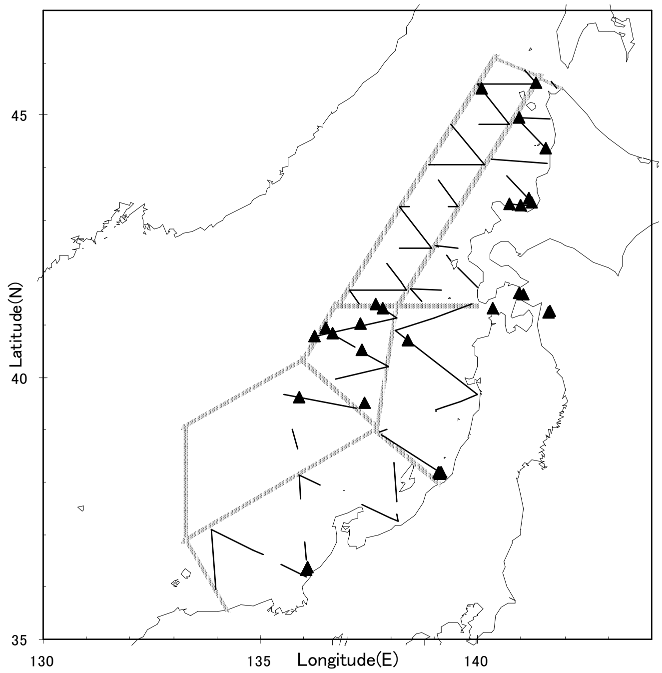

Fig. 5. Track line traversed with sighting effort and sighting positions of common minke whale schools in 2004. All sub-block covered by *Shonan-maru No.2*.

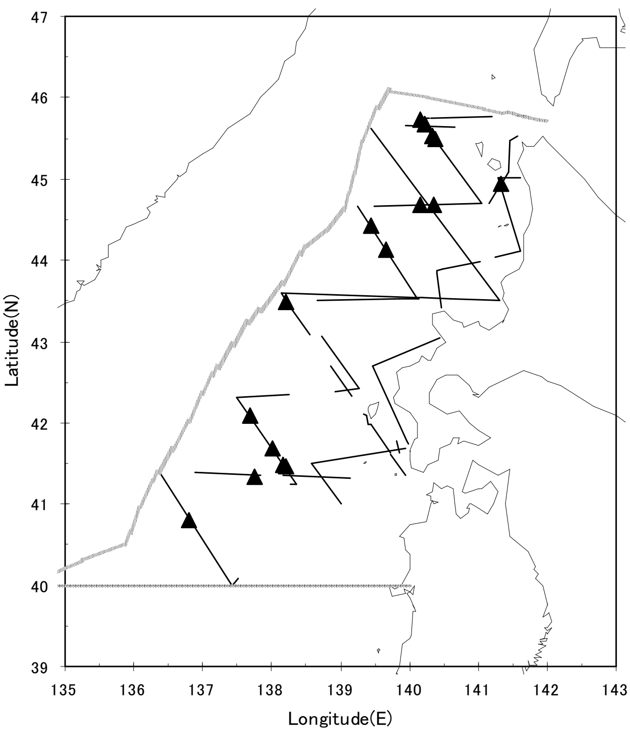

Fig. 6. Track line traversed with sighting effort and sighting positions of common minke whale schools in 2005. All sub-block covered by *Shonan-maru No.2*.

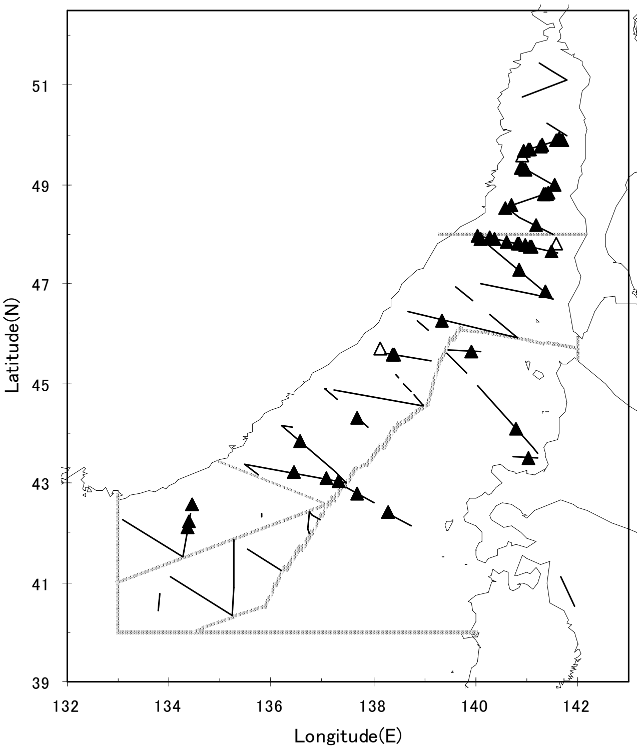

Fig. 7. Sighting positions of common minke whale school
during the *Kaiko-maru* IO sighting survey in the northern Sea of Japan in 2006.

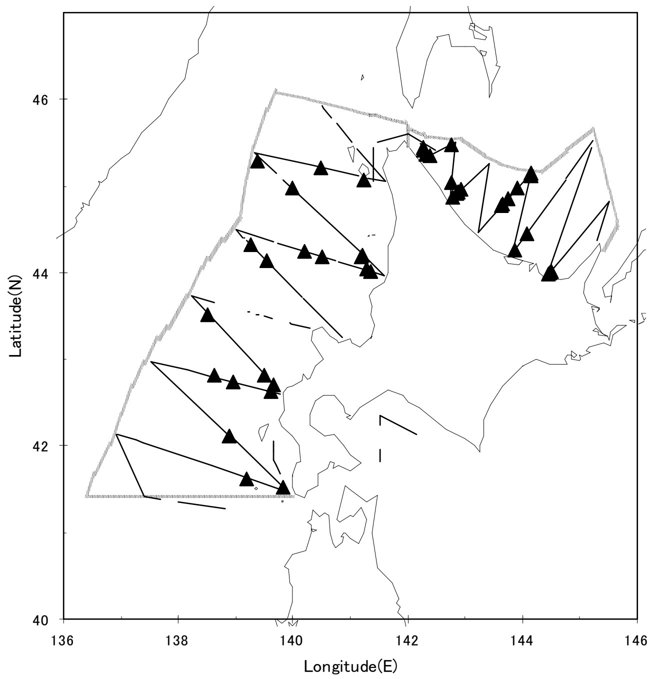

Fig. 8. Sighting positions of common minke whale school
during the *Shonan-maru No.2* IO sighting survey in the Sea of Japan and the Sea of Okhotsk in 2007.

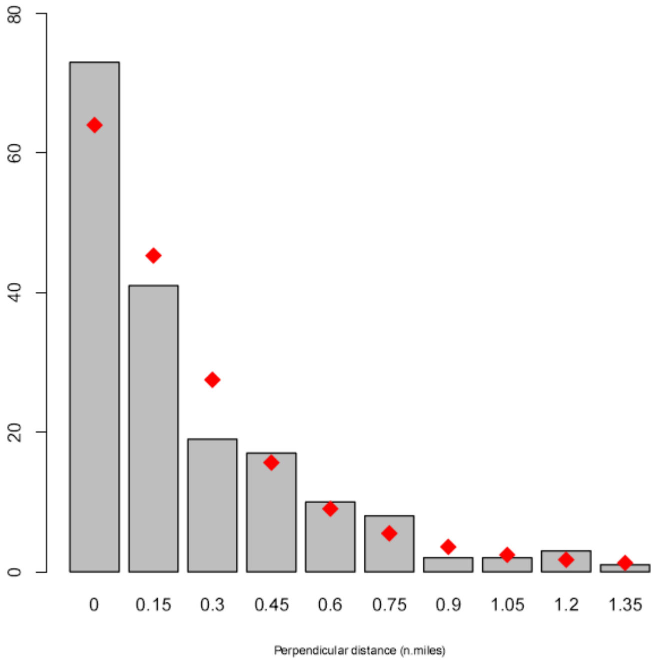

Fig 9. Perpendicular distance distribution and the fitness of detection curve.
Square shows the values of the best fit (Hazard rate model) to the observed values (bars).

Table 1. Japanese sighting data for the J–stock common minke whale abundance estimate.

No.	Year	Period	Vessel[1]	Searching distance (nmi)	No. sighting (sch. – ani.)		Area
					Pri.	Sec.	
1	2002	10 April – 9 May	*KSK*	389.7	5–7	2–2	6ES
2		13 May – 1 July	*SM2*	2,161.7	33–34	2–2	6EN, 10E
3	2003	11 April – 10 May	*KSK*	716.3	3–3	–	6ES
4		12 May – 30 June	*SM2*	1,877.8	27–31	5–5	6EN, 10E
5	2004	11 May – 29 June	*SM2*	1,898.1	14–14	11–13	6EN, 10E
6	2005	12 May – 30 June	*SM2*	841.5	11 –12	6–6	10E
7	2006	18 May – 28 June	*KKM*	1,852.2	51–55	6–6	10W, 10E
8	2007	18 May – 28 June	*SM2*	1,598.7	39–47	6–6	10E, 11

1: *KSK: Kurosaki, SM2: Shonan-maru No.2, KKM: Kaiko-maru.*

Table 2. Timing of the Japanese sighting surveys by block in the Sea of Japan.

Block	R/V	Season	April	May	June
10E	SM2	2002		16 ←→ 25	20 ←→ 26
		2003		14 ←→ 20	12 ←→ 26
		2004		24 ←	→ 16
		2005		12 ←	→ 30
		2007		31 ←	→ 25
10W	KKM	2006		21 ←	→ 21
6EN	SM2	2002		26 ←	→ 19
		2003		21 ←	→ 11
		2004		11 ←→ 23	17 ←→ 26
6ES	KSK	2002	12 ←	→ 6	
		2003	14 ←	→ 6	

Table 3. Model and covariate to estimate the abundance according to AIC. In the covariate columns, 1 means that the covariate was significant and selected and 0 not selected. HR: Hazard rate model, HN: Half normal model.

Covariate				model	esw	f(0)	log.lik	AIC
wind	area	vessel	year					
1	1	0	1	HR	0.361	2.770	54.423	−84.846
1	1	1	0	HR	0.371	2.698	51.322	−84.645
1	1	1	1	HR	0.370	2.702	51.357	−82.715
1	1	0	0	HR	0.410	2.441	48.186	−82.372
1	0	1	0	HR	0.396	2.528	45.502	−81.003
1	1	1	1	HR	0.361	2.770	54.423	−80.846
0	1	0	0	HN	0.478	2.090	37.203	−64.407
1	1	0	0	HN	0.476	2.102	37.854	−63.708
0	0	1	0	HN	0.505	1.979	30.564	−55.127
1	0	1	0	HN	0.500	1.998	31.550	−55.101
0	0	0	0	HN	0.521	1.920	27.228	−52.456
1	0	0	0	HN	0.517	1.935	28.110	−52.220

Table 4. Abundance estimate of J-stock common minke whales in the Sea of Japan using the Japanese data.

Season	Block	Area(nmi^2)	Research distance (nmi)	No. sightings	Abundance	Density	CV
2002	10E	27,823	485.8	10	816	0.0283	0.658
2003			651.1	7	405	0.0146	0.566
2004			860.7	7	474	0.0170	0.537
2005			841.5	8	666	0.0239	0.444
2007			1,051.4	16	575	0.0207	0.327
2006	10W	63,912	1,157.2	47	2,855	0.0447	0.327
2002	6EN	71,914	1,675.9	21	891	0.0124	0.608
2003			1,226.7	19	935	0.0130	0.357
2004			1,037.4	7	727	0.0101	0.372
2002	6ES	19,018	389.8	5	905	0.0476	0.684
2003			716.3	3	124	0.0065	0.582