Abundance estimates of common minke whales using the Japanese dedicated sighting survey data for RMP *Implementation* and CLA – Sea of Japan and Sea of Okhotsk

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ABSTRACT

Abundance estimate of common minke whales in the Sea of Japan and the Sea of Okhotsk (sub-areas 6, 10, 11 and 12) was conducted. All surveys were designed based on the IWC survey guideline for conducting surveys and analyzing data within the revised management scheme, and the survey activities were oversighted. Using sighting data from 2002 to 2007, the traditional line transect method taking into account of weather conditions assuming g(0)=1 was applied. For the independent observer survey data, the sightings from the top barrel and the upper bridge were used for analysis to keep the same condition with closing mode survey data. Survey design, effort coverage of the area and sighting positions were presented to evaluate whether the abundance estimate can be used for the RMP/IST and CLA. Range of abundance estimates including the past estimates in 1990's are as follows: Sea of Japan (727 – 1,795 in sub-area 6E, 2,476 in sub-area 10W, 405 – 816 in sub-area 10E), Sea of Okhotsk (377 – 2,120 in sub-area 11, 3,401 – 5,244 in sub-area 12SW, 10,397 – 13,067 in sub-area 12NE) and Pacific (420 in sub-area 9N) . Those values have downward bias because of assuming g(0)=1 and presence of un-surveyed area in the foreign 200 n.miles EEZ.

KEY WORD:COMMON MINKE WHALE,SIGHTING SURVEY,WESTERN NORTH PACIFIC

INTRODUCTION

Japan has conducted a series of sighting surveys for the abundance estimate of the East China Sea-Yellow Sea- the Sea of Japan stock of common minke whales (J-stock) under the cooperative project with Korea since 1994 in the Sea of Japan and the East China Sea (Iwasaki *et al*.,1995; Miyashita, 2001, 2002, 2004a, 2005, 2007; Miyashita and Yoshida, 2003). Based on the recent survey data from April to June, Miyashita *et al*. (2009) presented the abundance estimate for the J-stock in the Japanese survey area assuming g(0)=1 and Kitakado *et al*. (2009) presented the total J-stock abundance adding the estimates from the Korean surveys. On the other hand, for the Okhotsk Sea–western North Pacific stock (O-stock), Japan has conducted the sighting surveys especially in the Sea of Okhotsk and the waters east of Kuril archipelago and the Kamchatka peninsula (Miyashita *et al.* 1990, 1991, 2004b, 2006). Buckland *et al.* (1993) estimated the abundance of the O-stock from the surveys conducted in1989and1990. Miyashita (2010a) estimated the abundance estimates in the Sea of Okhotsk using 2003 data and those in the waters east of the Kuril archipelago and the Kamchatka peninsula using 2005 data. Miyashita (2010b) reviewed the survey design and results of the surveys such as the coverage of the sighting effort and the sighting position.

This document summarized the related documents (Miyashita *et al.* (2009), Miyashita (2010a)) about the common minke whale abundance estimates and information on the design of the surveys and the results of the surveys such as effort coverage of the area, sighting positions for these surveys used in the abundance estimates (Miyashita (2010b)) . And the past abundance estimates in 1990's are also listed for conditioning.

Materials and methods

Blocks used for the surveys

In the Sea of Japan, a total of four blocks were set to cover the Japanese side of the sea and the Russian EEZ (Fig 1). And the Japanese side block was divided into the coastal and offshore sub-blocks to take the density differences into consideration. In the Sea of Okhotsk, eight blocks were set (Fig. 2), but there were unsurveyed areas in the north-eastern area (north of 58^{o}N and east of 155^{o}E) due to the Russian restriction. In the waters east of the Kuril archipelago and the Kamchatka peninsula, a total of three blocks in the Russian EEZ were established (Fig. 3).

Survey period and pre-determined track line

Survey period was shown in Table 1. In the Sea of Japan, survey period was set from April to June when the Japanese small-type coastal whaling mainly caught the minke whales in the Sea of Japan. In 2002 and 2003, *Kurosaki* (KSK) covered block 6ES (Figs 4 and 6) from mid-April to mid-May, and *Shonan-maru No.2* (SM2) covered 6EN and 10E from mid-May to late-June (Figs 5 and 7), respectively. In 2004, SM2 covered blocks 6EN and 10E from mid-May to late-June (Fig. 8). In 2005, the Russian 200 n.miles EEZ (10W) was tried to cover first time, but no entry permission was issued from Russia. Then SM2 has covered twice 10E (Figs 9 and 10) and accumulated the sighing information from mid-May to late-June in 2005. 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 (Fig. 11) firstly. The pre-determined track line for KKM was same as for SM2 in the previous year. In 2007, SM2 conducted the IO passing mode survey north of Hokkaido (10E and sub-area 11) and 10E was covered in June (Fig. 12).

In the Sea of Okhotsk, the recent sighting survey was conducted in both sub-areas (11 and 12) in 2003 (Miyashita *et al*,2004b). (Figs 13 and 14). The research period was set between July to September (mainly in August) because mid-summer was assumed to be in the northward migration peak of O-stock common minke whales. The survey was conducted using two research vessels,SM2 and SM1 (*Shonan-maru*) (Table 1).

In the Pacific, the Russian 200 n.miles EEZ east of the Kuril archipelago and the Kamchatka peninsula was surveyed in 2005 by SM1 (Fig. 15) and SM2 (Fig. 16).

Track line was pre-determined to cover the sub-blocks or blocks uniformly and the start point was selected at random.

Survey direction

The direction to survey for each sub-block or block was shown in Figs 17- 29. Southward and northward direction was mixed considering the operational efficiency. For example, in the Japanese blocks in the Sea of Japan, when the coastal sub-blocks was covered southward, the offshore northward, and vice versa. When the vessel enters the Russian 200 n,miles EEZ or exits, the vessel must pass the check point determined by the Russian Federation, then the direction of survey should take it into account.

The start and finish dates for each sub-block or block were also shown in Figs 17 – 29. It is necessary to note that the research period shown in Table 1 includes the transit period between the port and the research area.

Coverage on effort

The track line traversed with sighting effort and the sighting positions of common minke whales were shown in Figs 30 – 37. There were sub-blocks or blocks with low coverage mainly because of bad weather conditions. Those were off shore sub-block in 6ES in the Sea of Japan in 2002 (Fig. 30), ONW, OSW, and OE in the Sea of Okhotsk in 2003 (Fig. 36). Additional reason in the case in 2003, there was an injury accident of crew rescued by the Japan Coast Guard. In the offshore sub-block 6EN in the Sea of Japan, there is vast training area of the Self-Defense Forces. Then the entrance was sometimes limited and the vessel did not enter (Fig. 20). In the case of entering the Russian 200 n.miles EEZ. the survey was continued in the waters as long as possible because it is necessary for passing the check point when the vessel enters and leaves the EEZ. Then sometimes there were not so much effort in the blocks outside the Russian EEZ such as the Sea of Japan in 2006 (Fig. 34) and the east of the Kuril archipelago in 200 5 (Fig. 37).

Blocks used for the abundance estimate

The blocks used for the abundance estimates were shown in Figs 38 - 45. The following blocks or area were not used the abundance estimate. The waters in 6EN in 2005 (Fig. 34), 10E and 6EN in 2006 (Fig. 35), OE in 2003 (Fig. 44) and KAN and the blocks outside of the Russian 200 n.miles EEZ in 2005 (Fig. 45). The reason of the exclusion was that the low coverage or no sightings.

Information on operation

All vessels have a top-barrel and are suitable for whale observation of which height from the sea level were about20m. KKM, SM1and SM2 have also an IO platform. In the usual closing mode and passing mode, two top men were primary observers and scientists on the upper bridge conducted the record of sighting. During the IO passing mode survey, additional two top men observed from the IO platform. The survey modes used in the surveys were shown in Table 1. Explanation of survey modes are as follows:

a. Normal Closing Mode (NCL)

Two topmen observe from the top barrel at all times. There are open communications between the top barrel and the upper bridge by microphone. When a sighting is made, the topman (or upper bridge observer) gives an estimate of the distance and angle to the sighting and the ship turns immediately, regardless of the angle to the sighting. The whales are approached and the species and number of animals estimated. All subsequent sightings are regarded as secondary until normal search effort is resumed. When a sighting is made, the person who made the sighting provides the sighting information. The ship then changes course to the appropriate heading to approach the whale, and vessel speed is increased as fast as possible to hasten the closure. Ship speed is decreased when the group is neared, usually at a distance of 0.2-0.4 n.miles from the initial sighting position.

After the whale group has been approached, the species, number of animals in the group, estimated body lengths, number of calves present, and other observation such as behavior recorded. After as many data as possible have been collected, other activities might take place, such as natural marking or biopsy experiments. Until the ship resumes transect with full search effort, any whale sightings made after the initial sighting are classified as secondary sightings.

b. Independent Observer Passing Mode (IO)

Two topmen on the top barrel and two topmen in the independent observer platform (IOP) observe at all time. Communications are essentially one-directional, with the topmen reporting information to the upper bridge observers, but no information being exchanged between the top barrel and IOP. The observers on the upper bridge should communicate with the topmen only to clarify information on the sightings. Immediately after a sighting is made from the barrel or IOP, the topman informs the upper bridge of his estimate of the distance and angle to the sighting, and after that, if possible, the species and number of animals present, but does not change his normal searching pattern in order to keep contact with the sighting. The observers on the upper bridge including the captain and the helmsman must attempt to locate the sighting made by the topman and decide whether it is possible for them to confirm the species and number before the sighting passes abeam of the vessel and also confirm the duplicate sightings or not. The topman gives no further information to the upper bridge unless the whale group happens to surface again within the normal searching pattern of the topman.

All sightings made during the IO mode are primary sightings.

c. Independent Observer Abeam Closing Mode (IOA)

This mode was used only in the 2003 Okhotsk sighting surveys in order to increase the possibility for color type identification of Dall's porpoises. Sighting method is same as the IO mode (two topmen on the barrel and two topmen on the IOP, no communication between two places), but when the sighting is Dall's porpoise and the abeam distance is less than two n.miles, the vessel closes the sighting just after pasting abeam of the vessel. If the color type of Dall's porpoises was identified before passing abeam, the vessel does not close the sighting and continue passing. After closing the sighting, the observation method was same as NCM. After observation is finished, the vessel returns to the position of abeam of vessel where abeam closing was begun and resumes the IO mode survey.

The sightings made during closing and return to the abeam point are classified as secondary sightings.

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. In the Okhotsk Sea cruise in 2003, IO passing mode and IO passing mode with abeam closing to Dall's porpoise school were used alternately by track line (Miyashita 2004b). Abeam closing was used to increase the accuracy for color type identification of Dall's porpoise because two color types of the species migrate into the area.

The surveys were conducted under the suitable weather conditions. In the Sea of Japan, because the sea conditions seem to be better than the northern waters such as the Sea of Okhotsk, the survey by closing mode was conducted using the binoculars when the visibility better than 2 n.miles and the wind force less than four. On other hand, during the IO mode surveys in the Sea of Japan in 2006, in the Okhotsk Sea in 2003 and the waters east of the Kuril archipelago and the Kamchatka peninsula in 2005, sightings were made by naked eyes when the visibility is better than1.5n.miles and the wind force is less than 3 in Beaufort scale. All information from four observers was recorded independently using voice recording system and monitored at the upper bridge. The scientists at the upper bridge confirmed whether the sighting was duplicate sighting or not and also time lag of duplicate sightings. The daily survey started at 06:00 a.m. or 30 minutes after sunrise and finished at 30 minutes before the sunset, but the daily research duration was set as shorter than 12 hours.

Abundance estimate method

The detection probability was estimated using Multiple Covariate Distance Sampling (MCDS) (Buckland *et al.*, 2004). Hazard rate probability curve and half normal curve were candidates as the key function of detection curve in this study. The scale parameter of detection function was linked to weather (wind force), survey area, vessel and year. The parameters were estimated using a maximum likelihood approach (Buckland *et al.* 2004). The best model was selected using AIC. The probability to detect common minke whales on the track line was assumed as g(0)=1.

The school size was not dealt with as a covariate in detection function. Instead, the traditional regression analysis was used where log(s) was regressed against g(x) (Buckland *et al.* 2004).

The abundance estimate in block *i* was calculated by

$$\hat{N}_i = \frac{n_i \cdot \hat{E}[s_i] \cdot \hat{f}(0) \cdot A_i}{2L_i},$$

where n_i is number of primary sightings, $\hat{f}(0)$ is the probability density of distance zero, $\hat{E}[s_i]$ is mean school size, L_i is research distance and A_i is size of the area.

The variance of abundance estimate was calculated using a delta method (Buckland *et al.*2004).

The 95% confidence interval of the total abundance is calculated as following formula (Buckland *et al.*, 2004),

$$\left(N/C, N \cdot C\right),$$

where

$$C = \exp\left\{1.96 \cdot \sqrt{\ln\left\{1 + \frac{\hat{\text{var}}(\hat{N})}{\hat{N}^2}\right\}}\right\}$$

RESULTS AND DISCUSSION

Sea of Japan (sub-areas 6 and 10)

Information on model selection and covariates used to estimate abundances are listed in Table 2. 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. 46.

The estimates of abundance by block and year are shown in Table 3. 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, 2005). 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, 2005). 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 n, 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. 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; 2005; 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.

Sea of Okhotsk and Russian EEZ east of the Kuril archipelago and the Kamchatka peninsula

Research distance in the Sea of Okhotsk in 2003 was 903nmi by SM1, 1,805 nmi by SM2, respectively. The reason of less effort by SM1 is the bad weather and the time loss due to the accident of injury of the crew (Miyashita, 2006). Therefore the coverage of the central blocks (OSW, ONW and OE) was not so good (Fig. 36).

Research distance in the waters east of the Kurile archipelago – Kamchatka was 1,441nmi by SM1, 929nmi by SM2, respectively. Because the Russian EEZ has priority to be surveyed and the bad weather especially dense fog disturbed the survey for a long time, the coverage in the high seas blocks (PAW, PAE, KAS and BES) was low. Number of primary sightings was SM1: 5 schools - 5 animals, SM2: 6 schools - 6 animals.

Using primary sightings on the top-barrel and upper-bridge through these cruises during the IO mode sighting surveys, other IO sighting surveys in the Sea of Japan in 2006 and 2007 was also used for estimate of the probability density of distance zero. The model selected for key function was half normal model and significant covariates were 'wind' (Table 4). Fitness of the detection curve to the observed values is shown in Fig. 47.

Results of abundance estimate by block are shown in Table 5. Because the Russian territorial waters was not covered, there the unsurveyed area remained in the northeastern coastal waters in the Sea of Okhotsk and g(0) was assumed as 1, the present abundance estimate has under bias. Especially it is well known that common minke whales move into the very coastal waters such as bay, the coastal survey is necessary in the future to evaluate the number in these waters.

Abundance estimate by sub-area

Abundance estimate by sub-area are summarized from Tables 3 and 5 and shown in Table 6. Also Table 6 includes the past estimate used in the last RMP *Implementation*. Those estimates are based on the sightings on the top barrel and the upper bridge during the all surveys modes (normal closing, IO passing, IO abeam closing). Therefore the present estimates can be compatible and can be used for the RMP *Implementation* and the CLA. However those estimates are assumed g(0)=1 and un-surveyed area have remained especially in the coastal waters off Russia, which causes downward bias of estimate.

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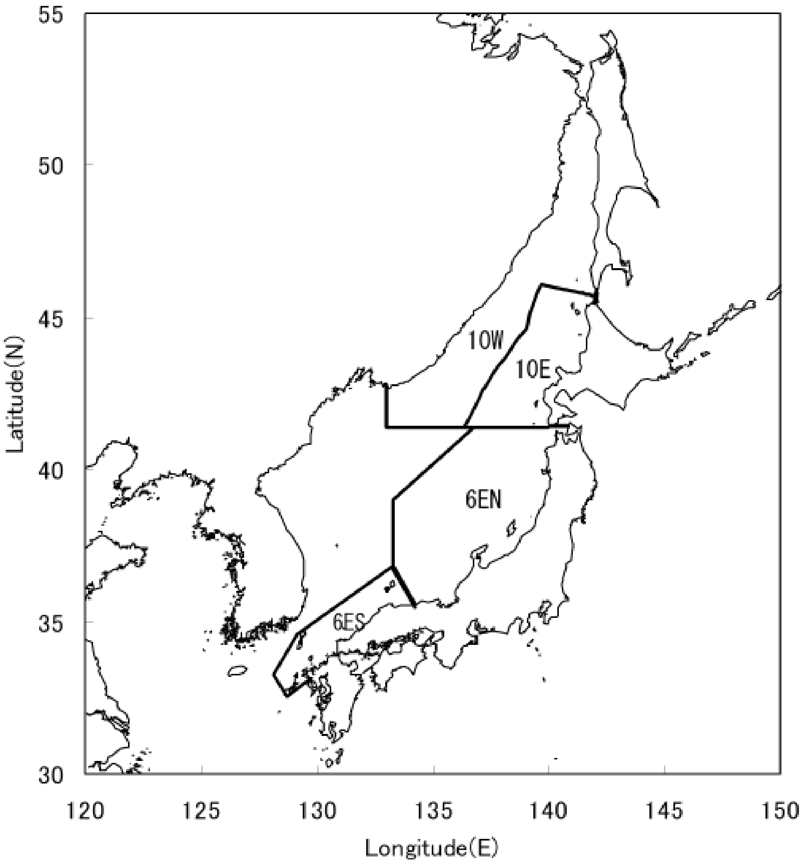

Fig. 1. Blocks surveyed in the Sea of Japan.

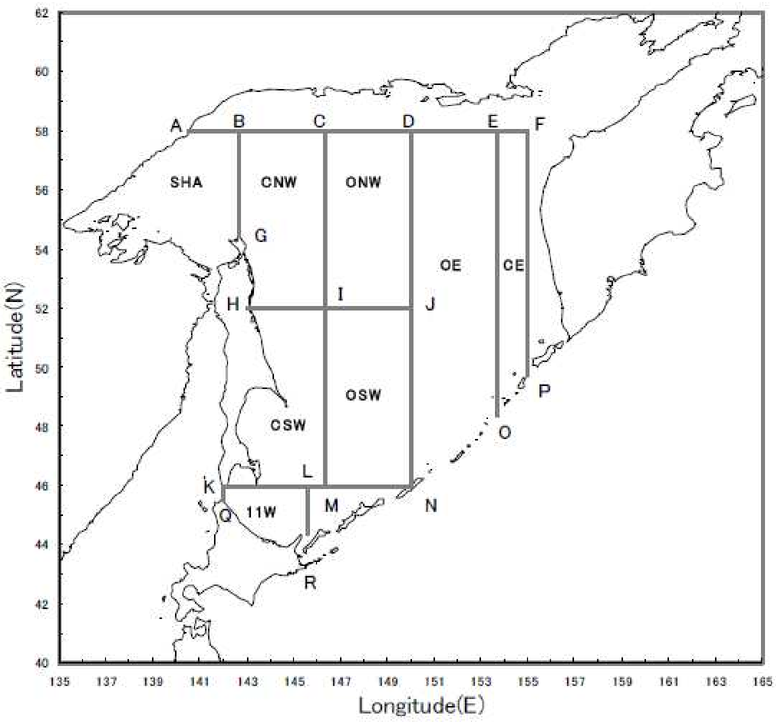

Fig. 2. Blocks surveyed in the Sea of Okhotsk. Alphabet (A-R) shows way-points for block definition.

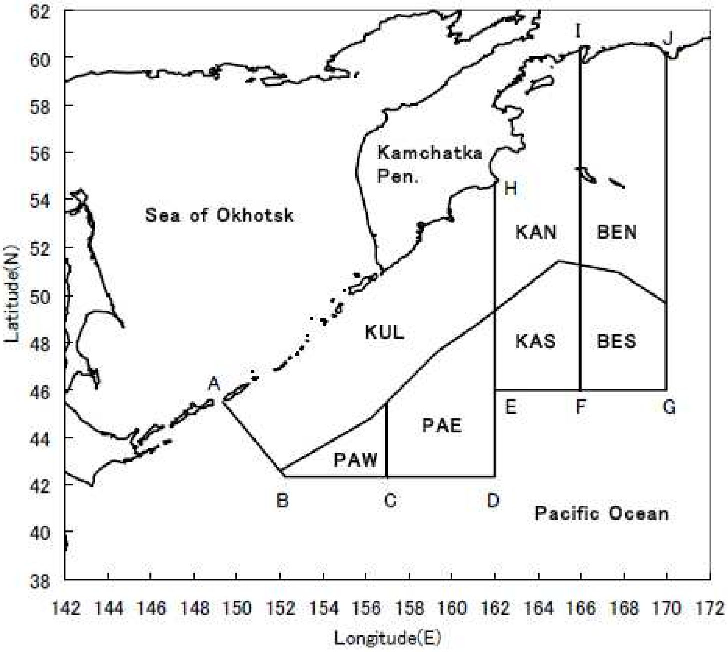

Fig. 3. Blocks surveyed in the waters east of the Kuril archipelago and the Kamchatka peninsula.
KUL, KAN and BEN cover the Russian 200 n.miles EEZ. Alphabet (A-G) shows way points for block definition.

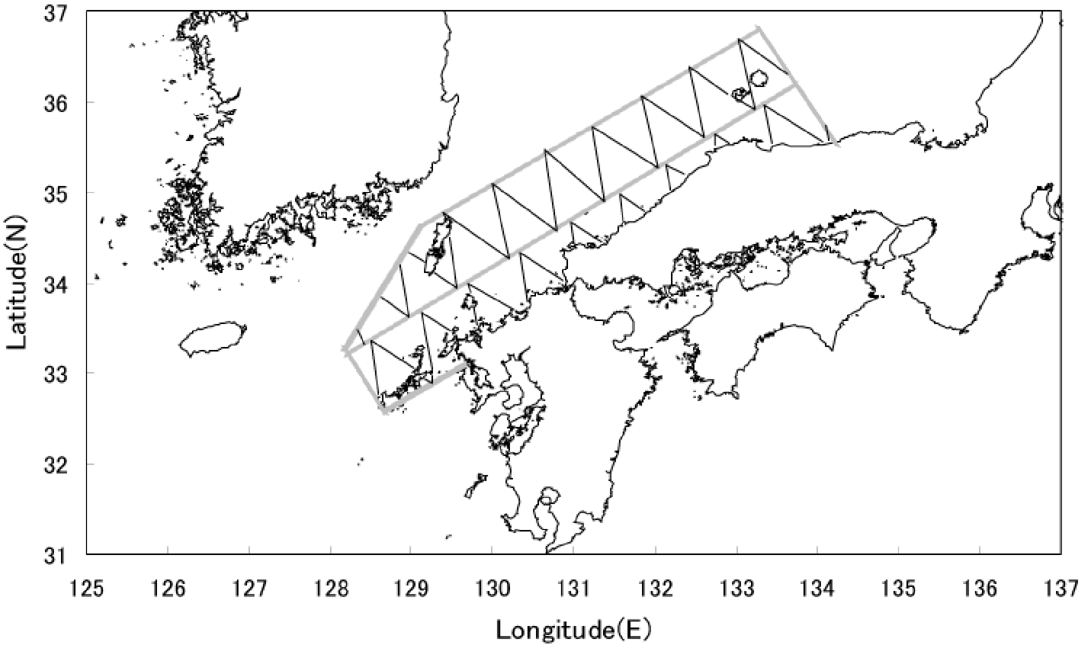

Fig. 4. Pre-determined track for *Kurosaki*, 10 April – 9 May in 2002.

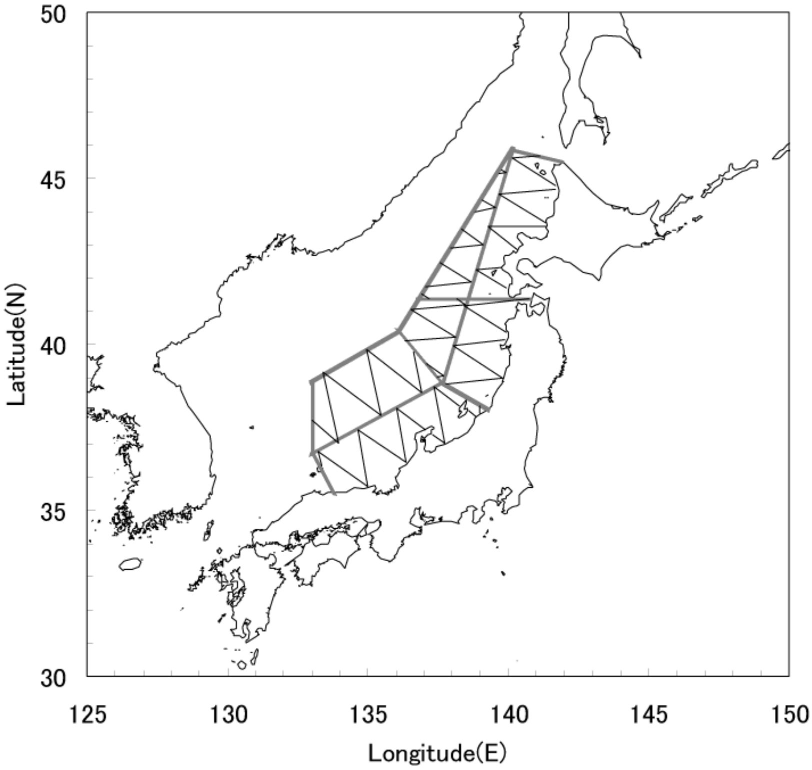

Fig. 5. Pre-determined track line for *Shonan-maru No.2*, 13 May – 1 July in 2002.

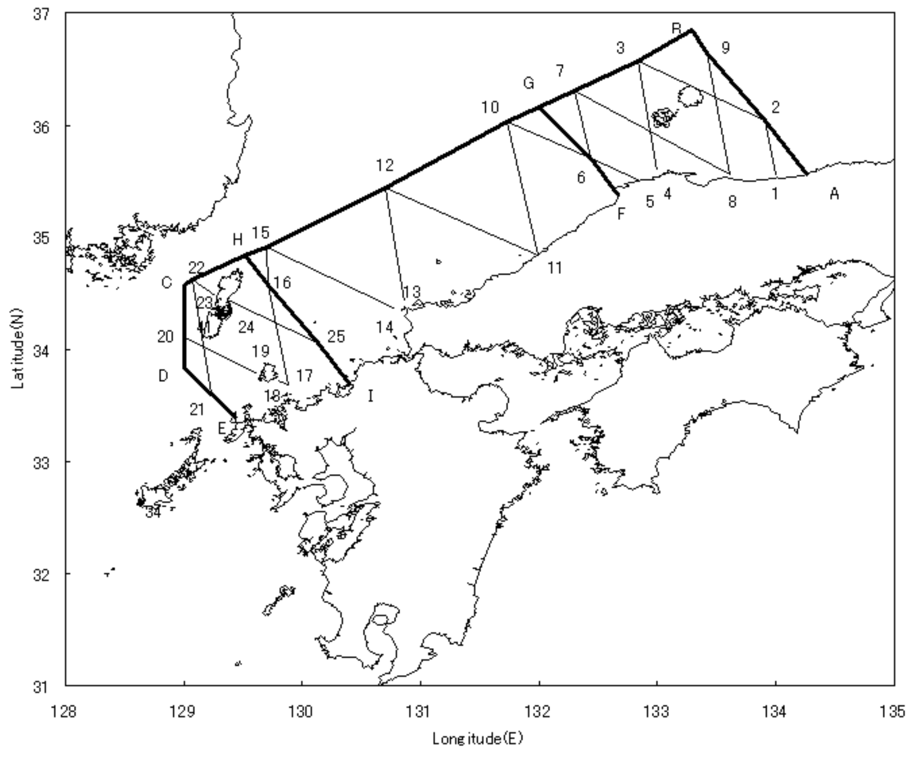

Fig. 6. Pre-determined track line for *Kurosaki*, 11 April – 10 May in 2003.

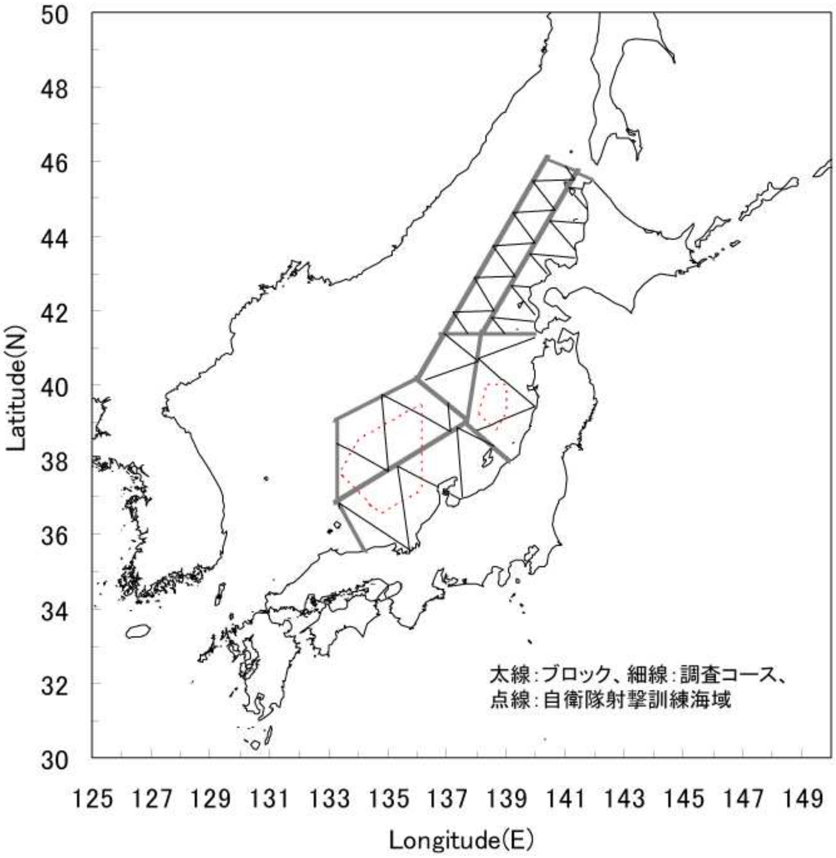

Fig. 7. Pre-determined track line for *Shoanan-maru No.2*, 12 May – 30 June in 2003. Dotted area shows the training area of the Self-Defense Forces.

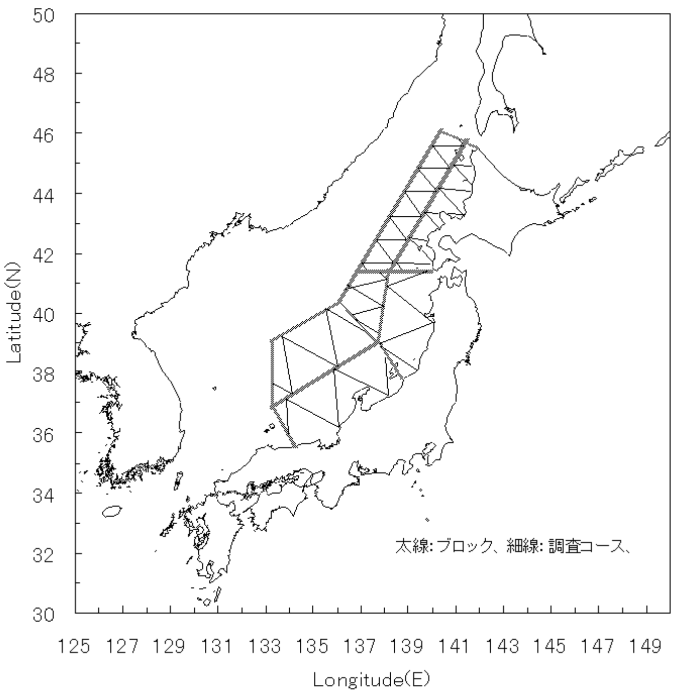

Fig. 8. Pre-determined track line for *Shoanan-maru No.2*, 11 May – 29 June in 2004.

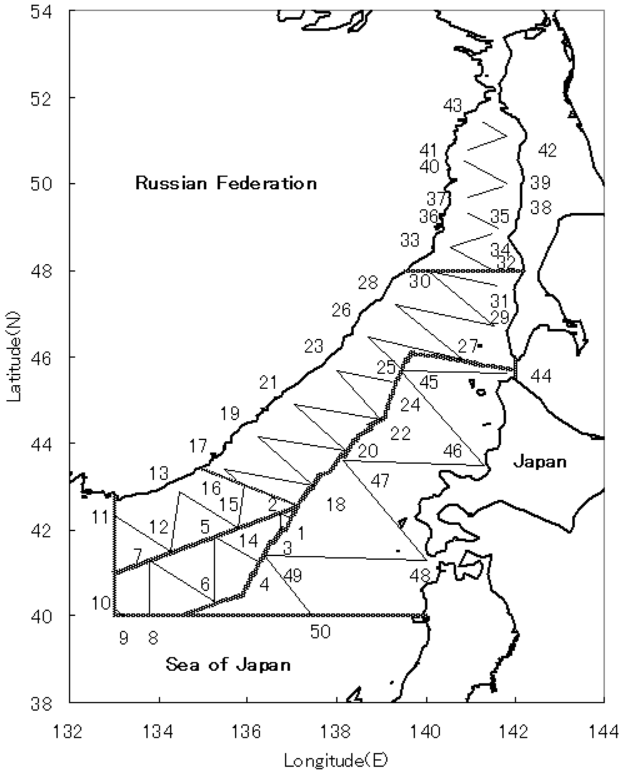

Fig. 9. Pre-determined track line for *Shonan-maru No.2*, 12 May – 30 June in 2005. Because the Russian permission to survey in the 200 n.mile EEZ was not issued, the vessel covered only in the Japanese side block in the first period, 12 May – 4 June in 2005.

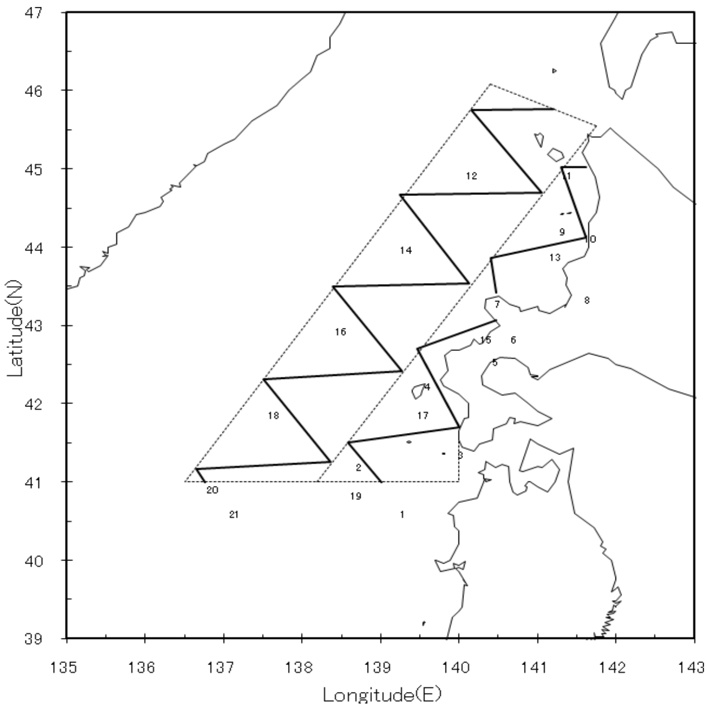

Fig. 10. Revised pre-determined track line for *Shonan-maru No.2* for the last period, 5 June – 30 June in 2005.

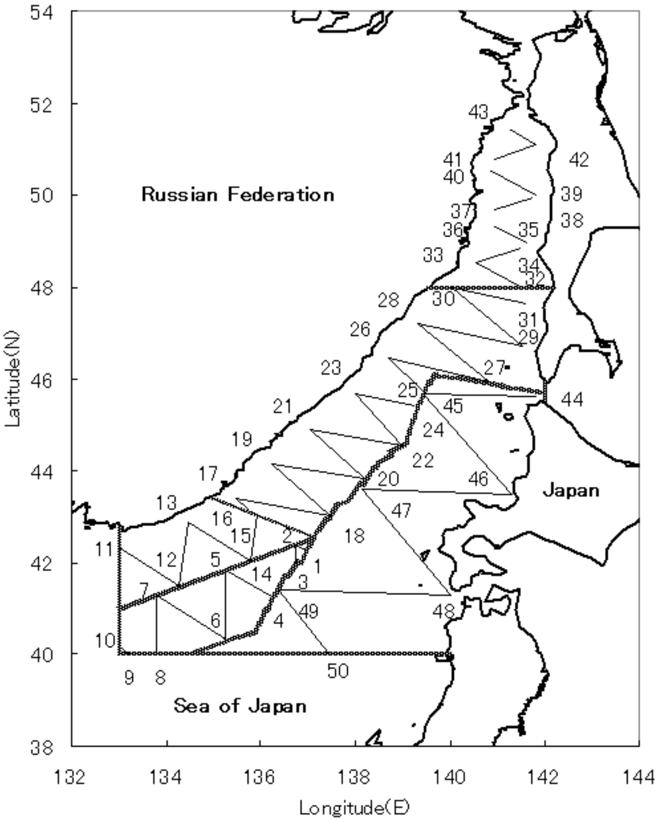

Fig. 11. Pre-determined track line for *Kaiko-maru*, 18 May – 28 June in 2006.

It was same for *Shonan-maru No.2* in 2005 cruise (Fig. 9).

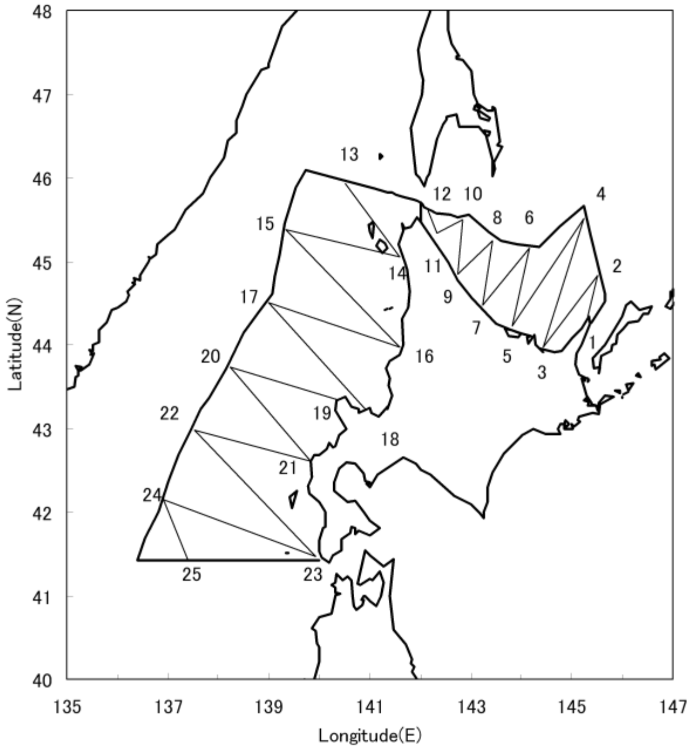

Fig. 12. Pre-determined track line for *Shonan-maru No.2*, 18 May – 28 June in 2007.

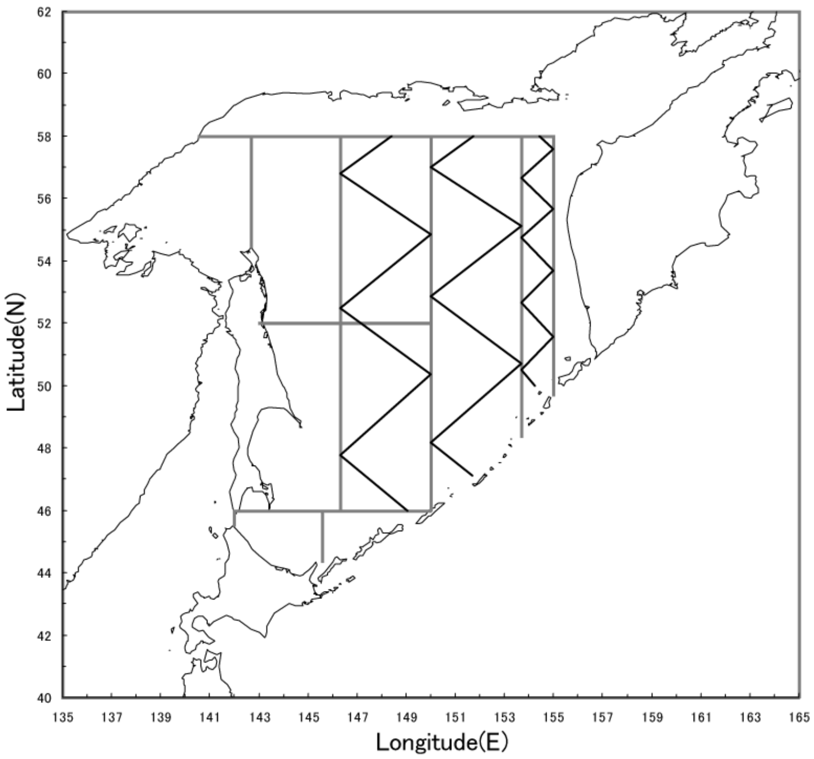

Fig. 13. Pre-determined track line for *Shonan-maru*, 22 July – 19 September in 2003.

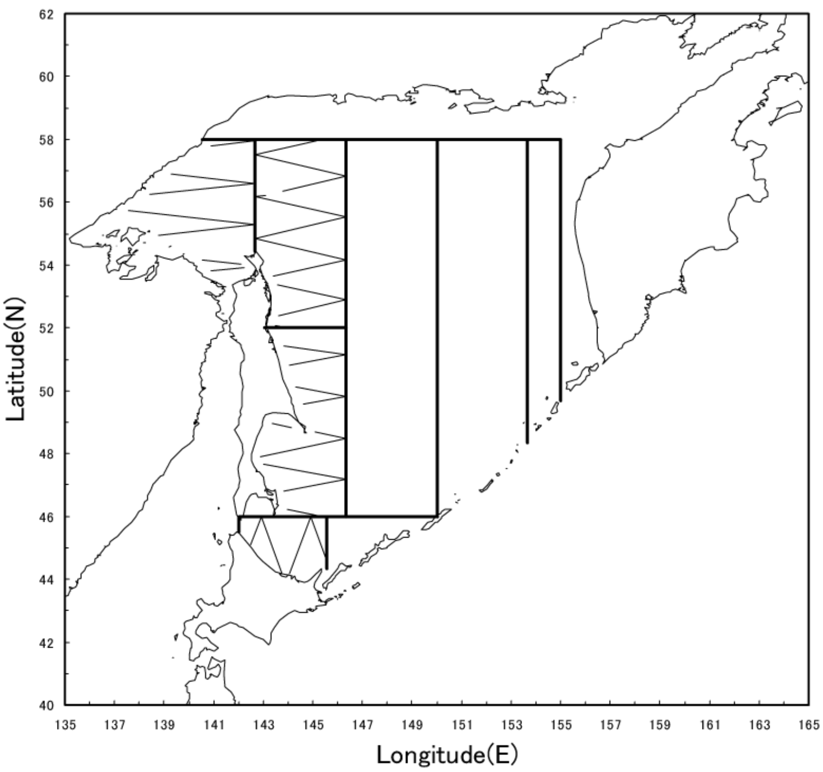

Fig. 14. Pre-determined track line for *Shonan-maru No.2*, 22 July – 19 September in 2003.

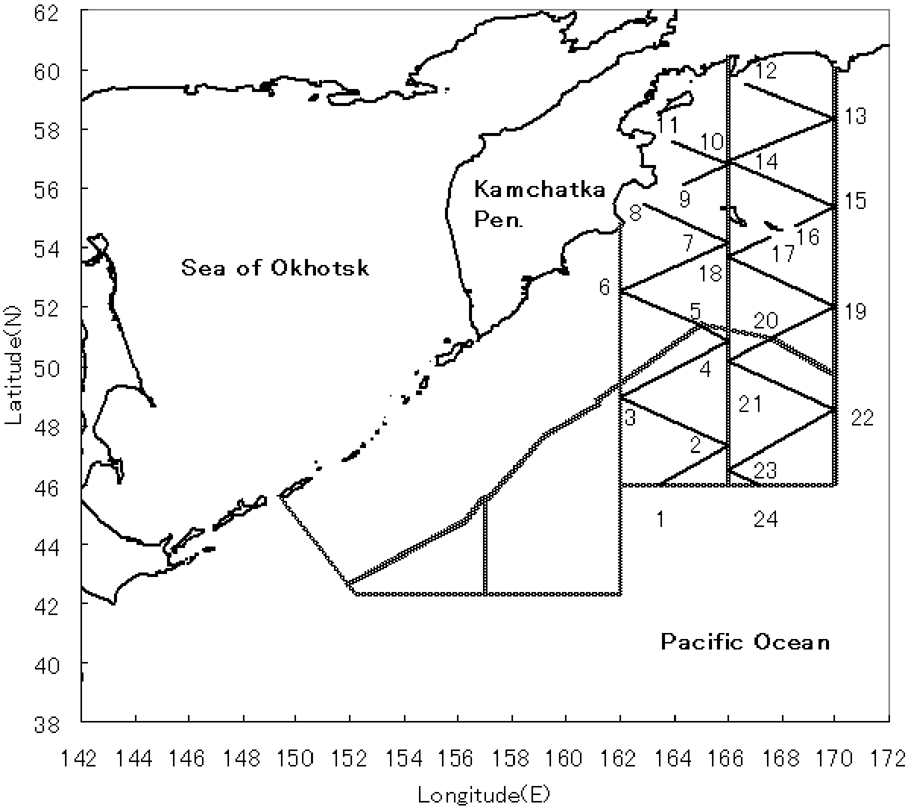

Fig. 15. Pre-determined track line for Shonan-maru, 29 July – 20 September in 2005.

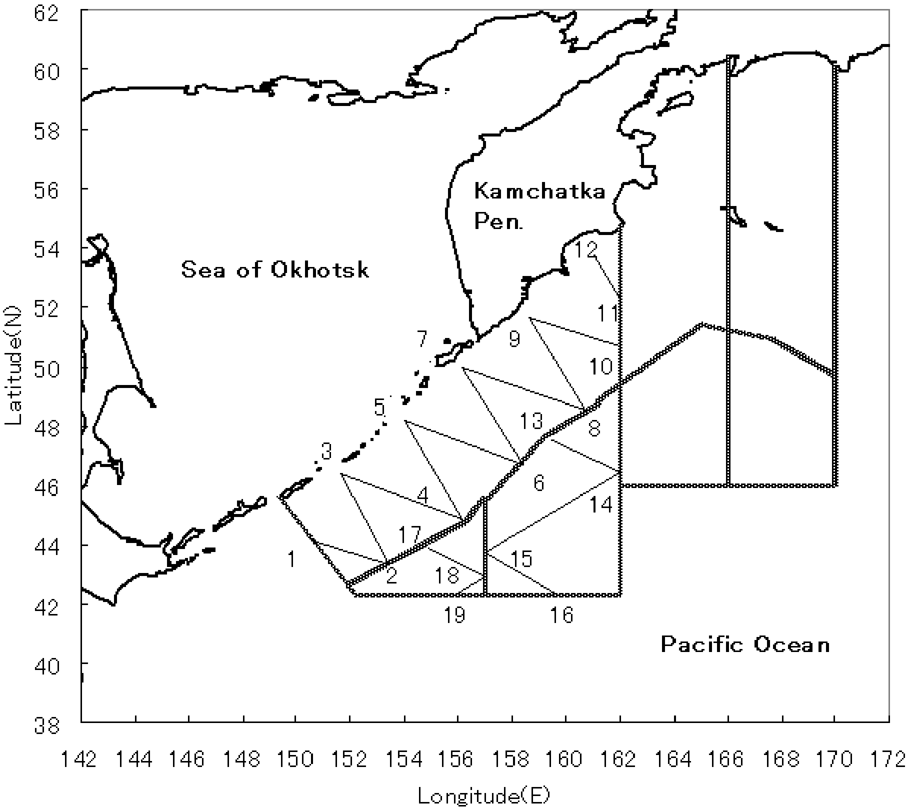

Fig. 16. Pre-determined track line for Shonan-maru No.2, 29 July – 20 September in 2005.

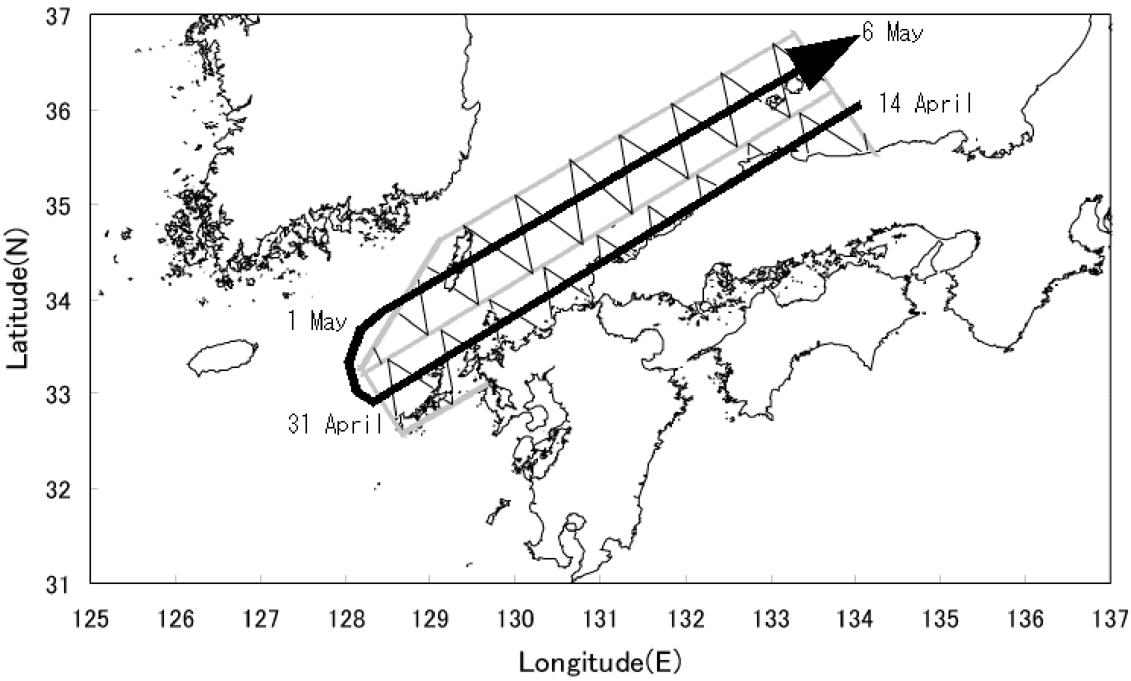

Fig. 17. Survey direction of *Kurosaki* in 2002.
Date shows the day to start/finish survey in each sub-block.

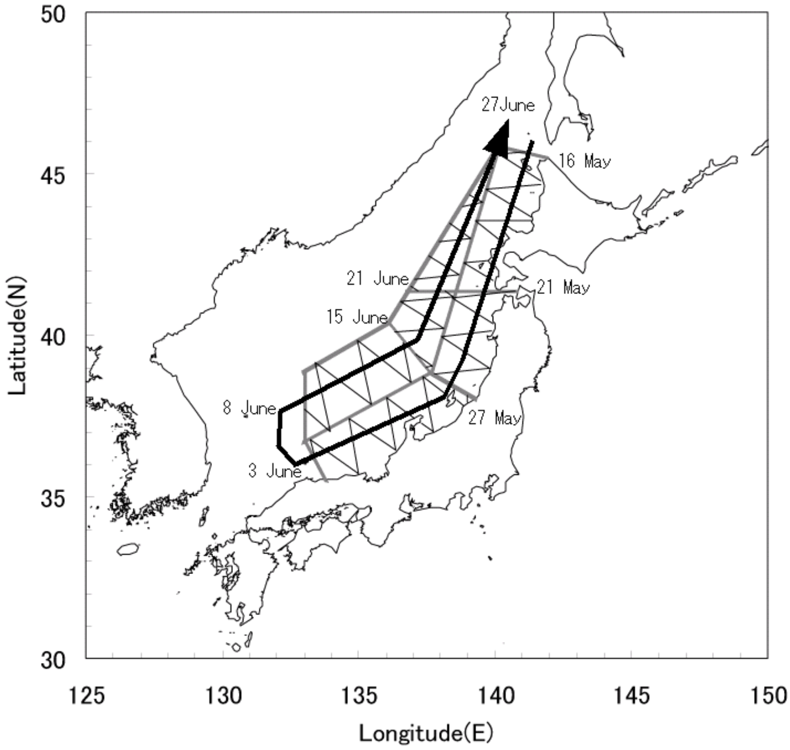

Fig. 18. Survey direction of *Shonan-maru No.2* in 2002.

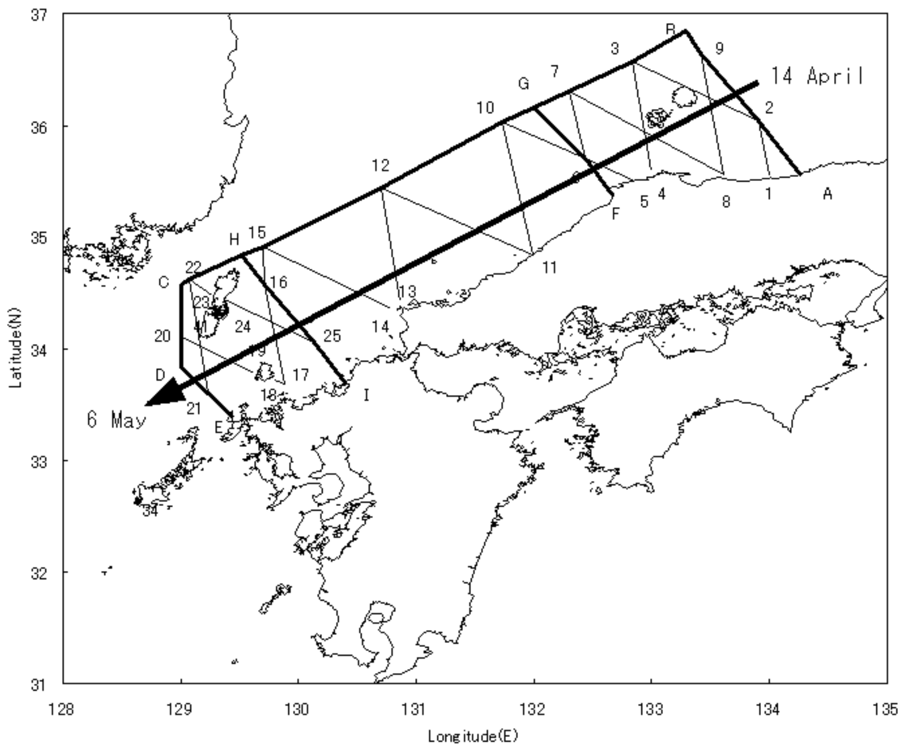

Fig. 19. Survey direction of *Kurosaki* in 2003.

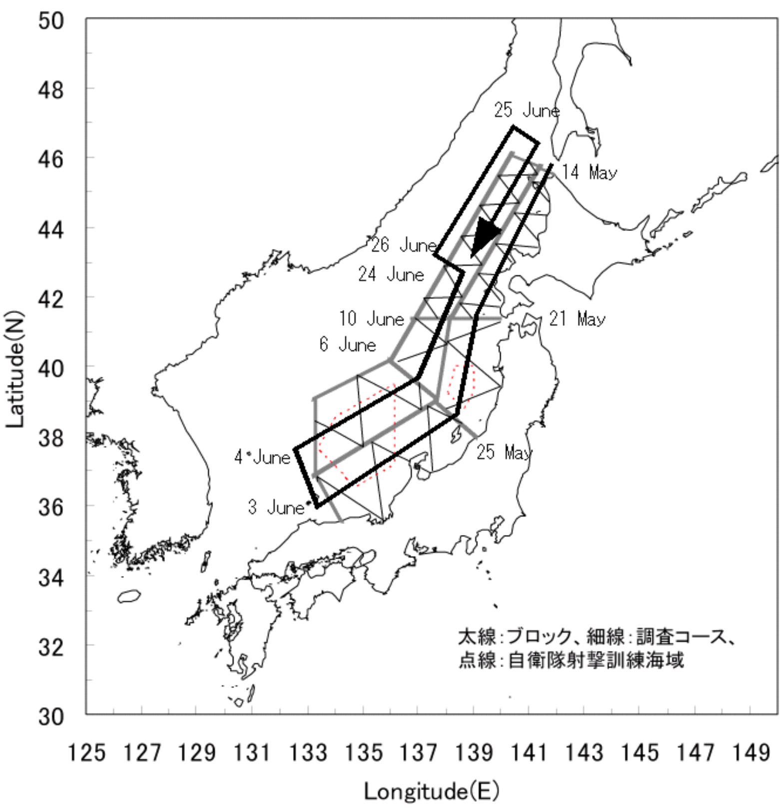

Fig. 20. Survey direction of *Shonan-maru No.2* in 2003.

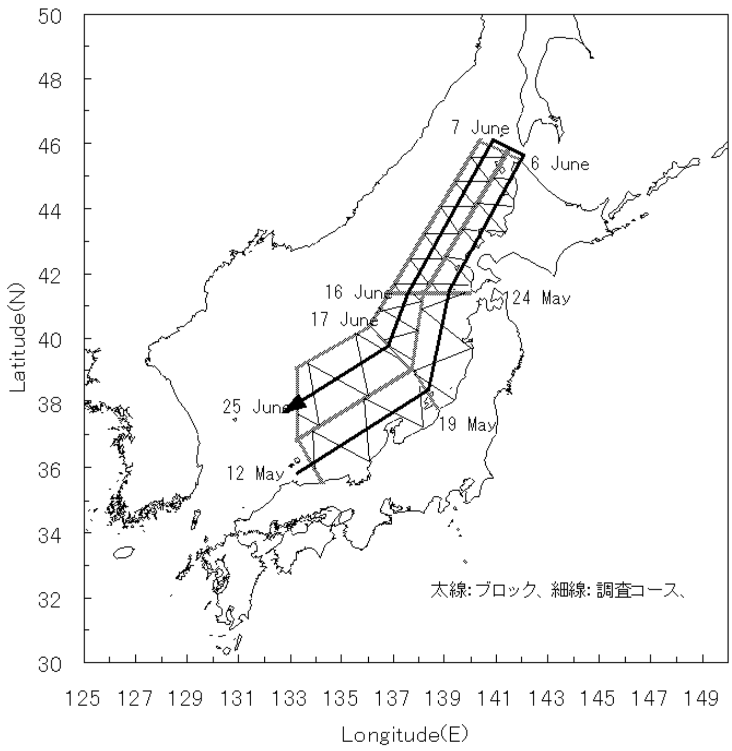

Fig. 21. Survey direction of *Shonan-maru No.2* in 2004.

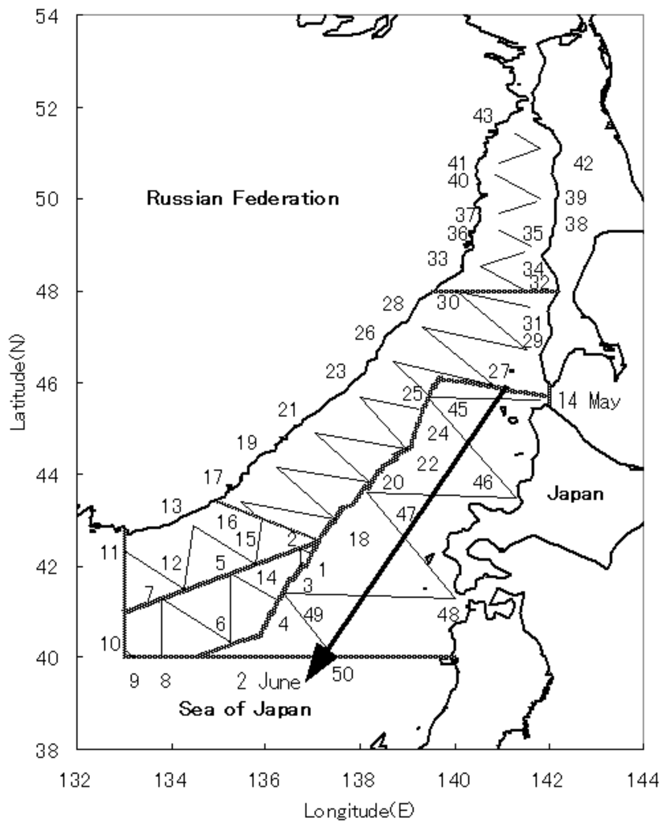

Fig. 22. Survey direction of *Shonan-maru No.2* in the first half of the cruise in 2005.

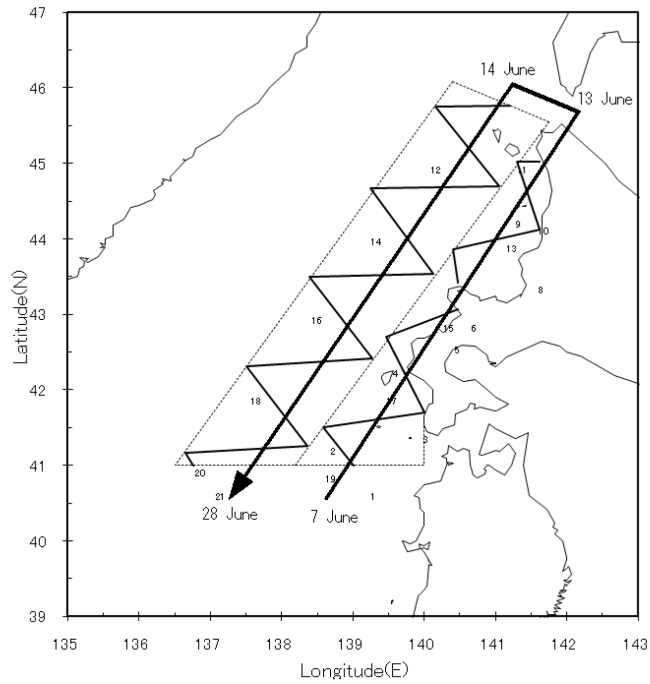

Fig. 23. Survey direction of *Shonan-maru No.2 i*n the last half of the cruise in 2005.

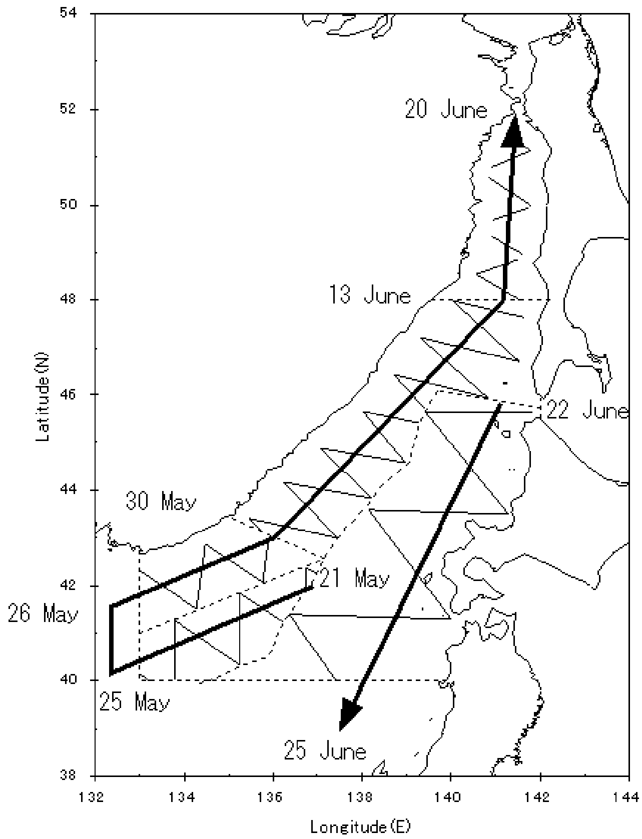

Fig. 24. Survey direction of *Kaiko-maru* in 2006.

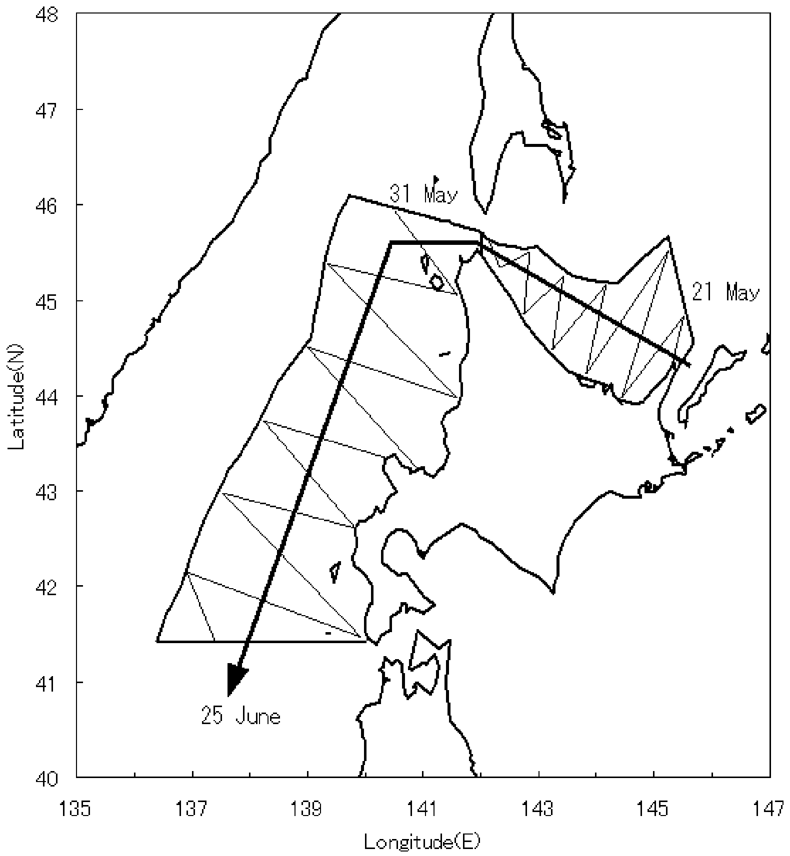

Fig. 25. Survey direction of *Shonan-maru No.2* in 2007.

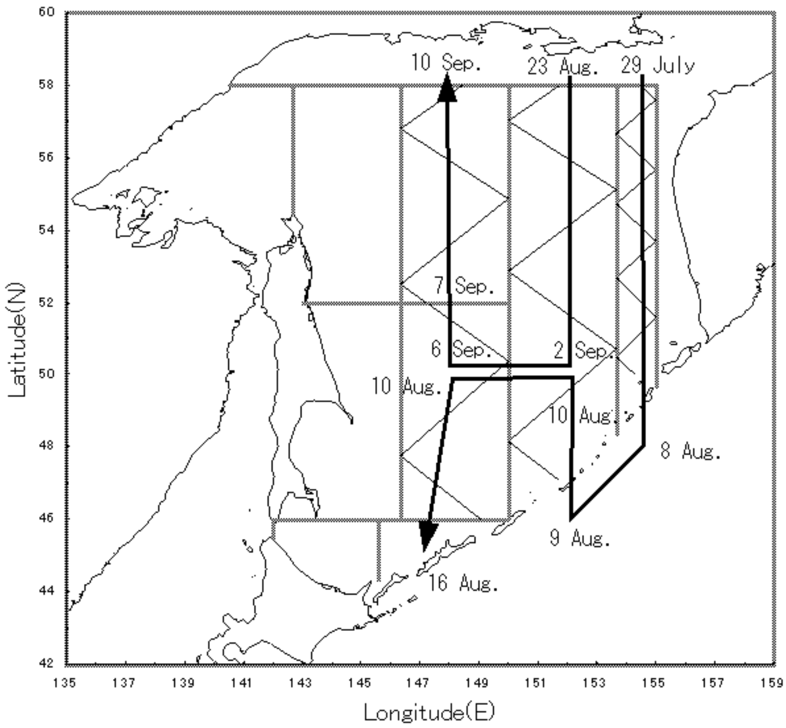

Fig. 26. Survey direction of *Shonan-maru* in 2003.

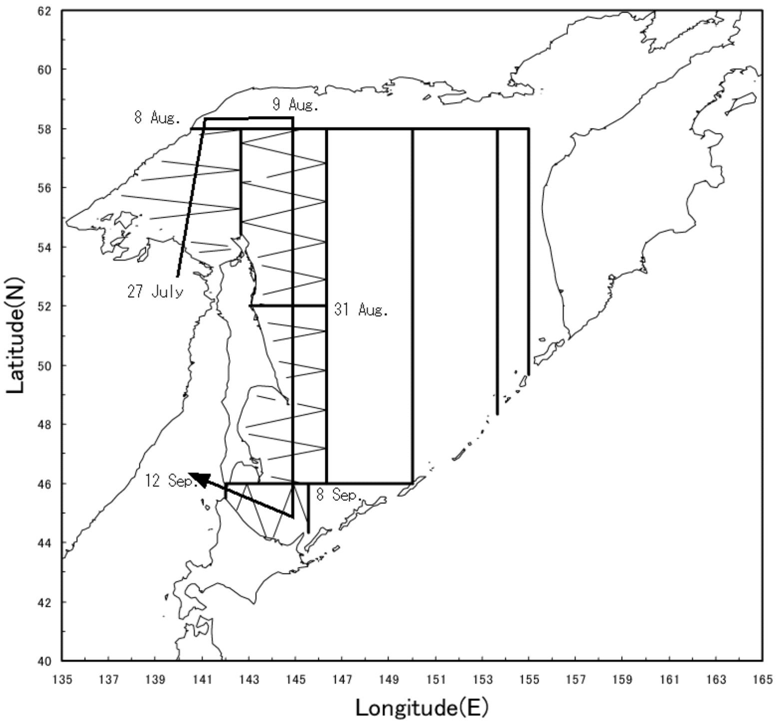

Fig. 27. Survey direction of *Shonan-maru No.2* in 2003.

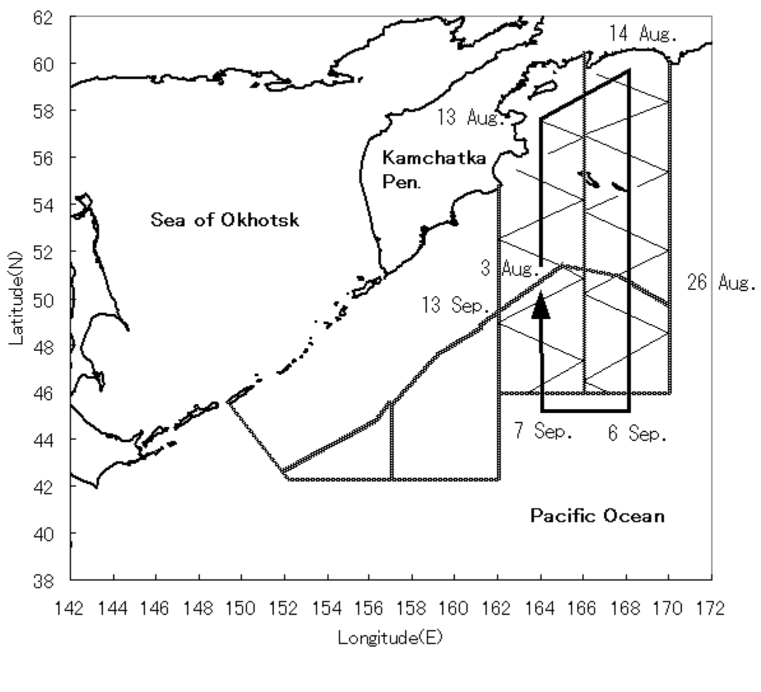

Fig. 28. Survey direction of *Shonan-maru* in 2005.

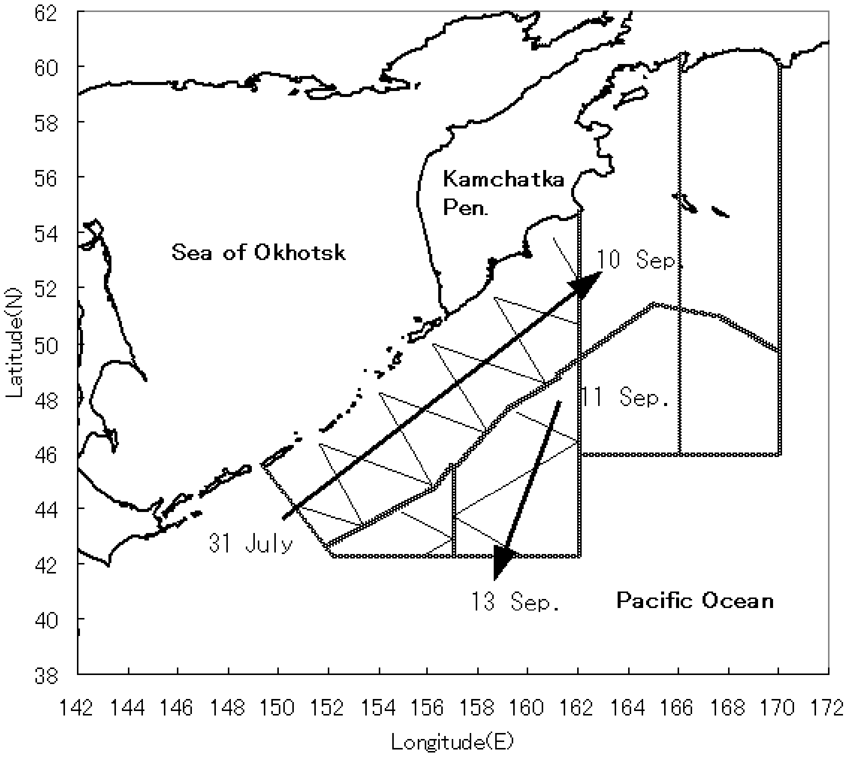

Fig. 29. Survey direction of *Shonan-maru No.2* in 2005.

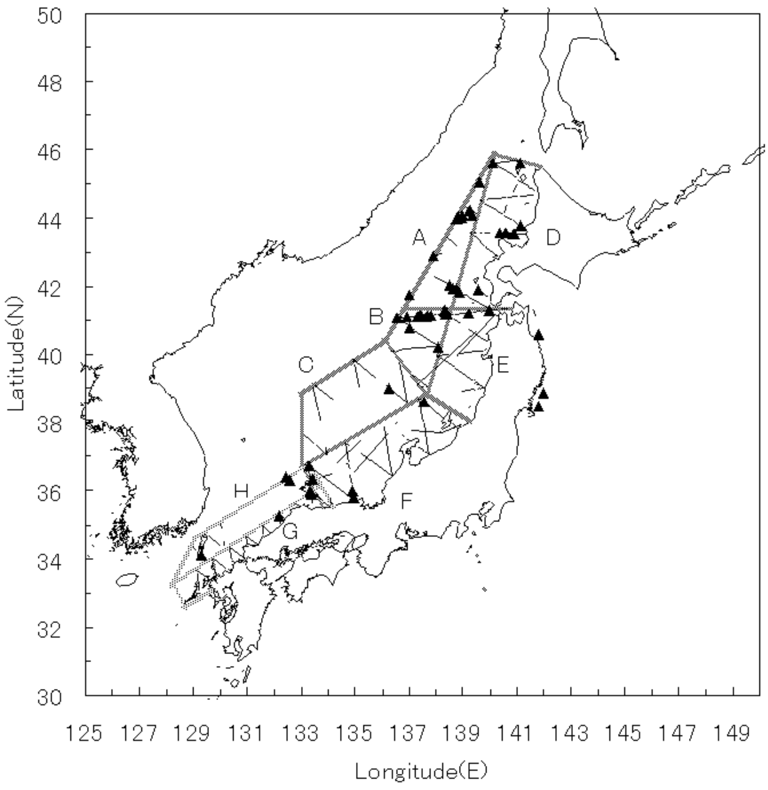

Fig. 30. Track line traversed on effort and sighting positions of common minke whale schools in the Sea of Japan in 2002.

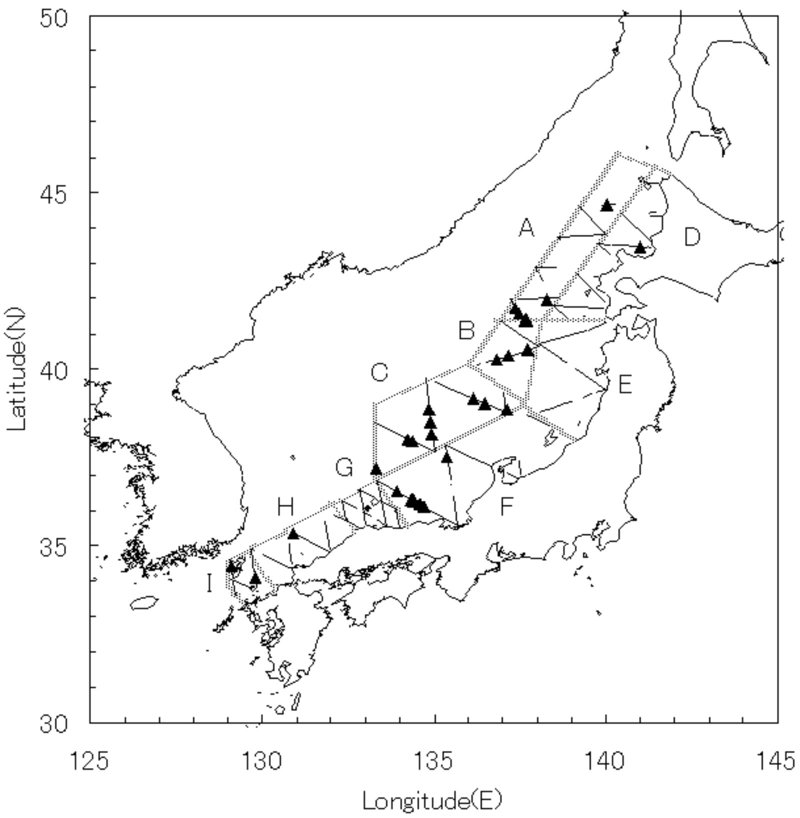

Fig. 31. Track line traversed on effort and sighting positions of common minke whale schools in the Sea of Japan in 2003.

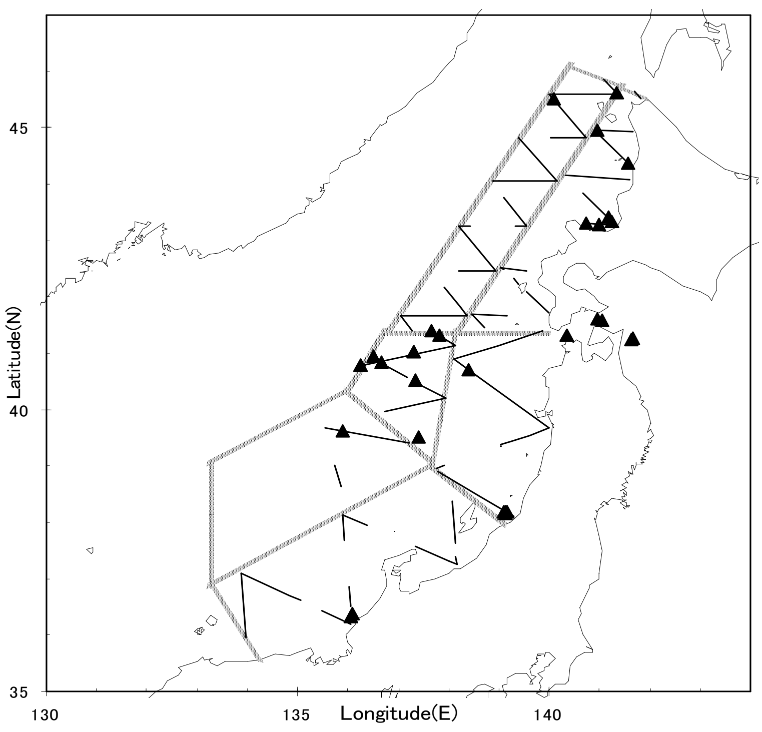

Fig. 32. Track line traversed on effort and sighting positions of common minke whale schools in the Sea of Japan in 2004.

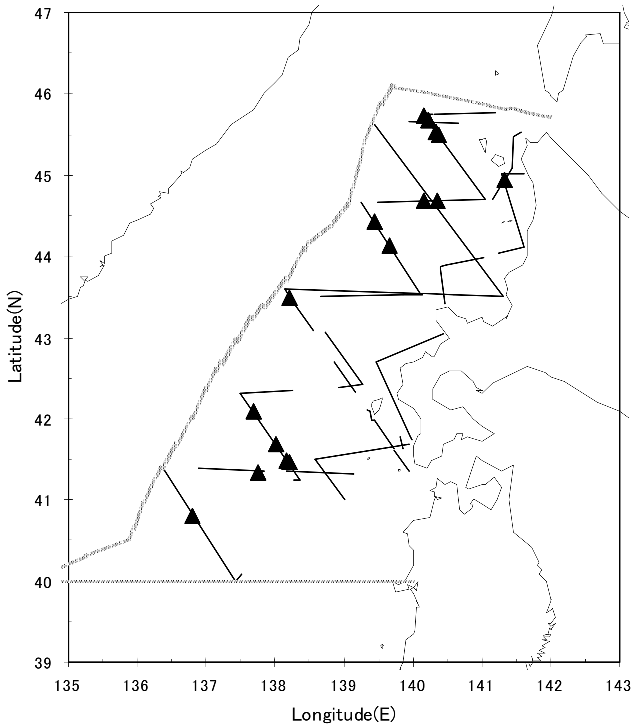

Fig. 33. Track line traversed on effort and sighting positions of common minke whale schools in the Sea of Japan in 2005.

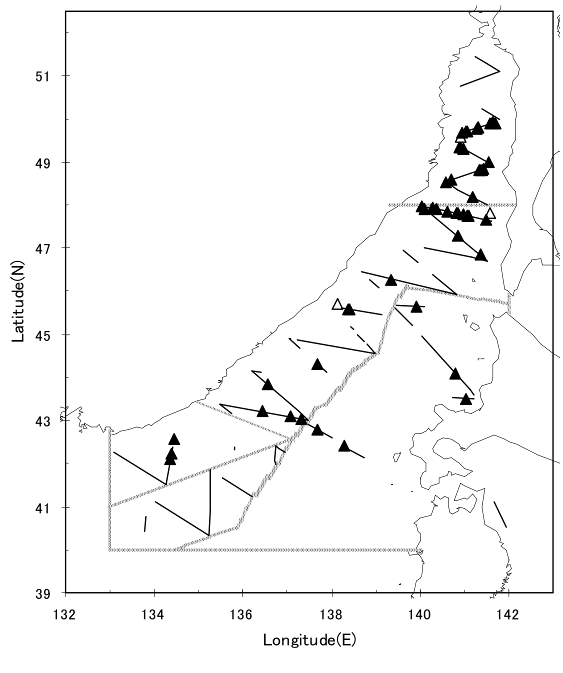

Fig. 34. Track line traversed on effort and sighting positions of common minke whale schools in the Sea of Japan in 2006.

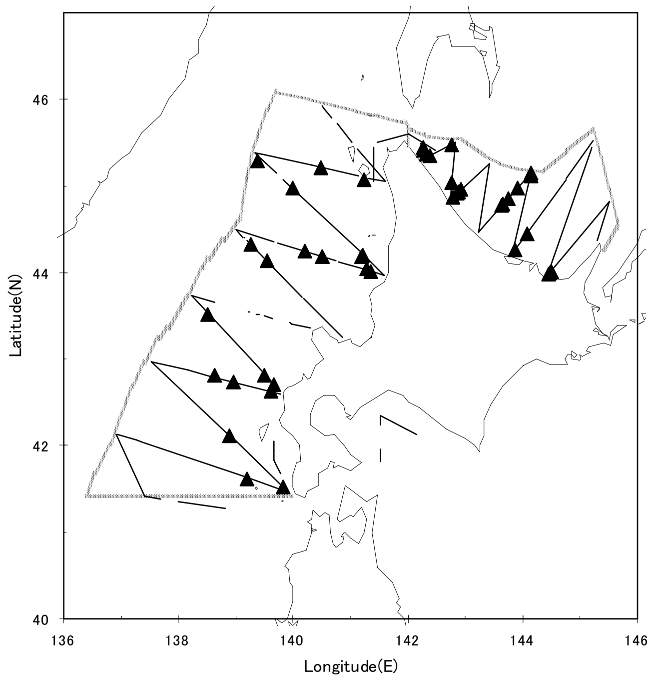

Fig. 35. Track line traversed on effort and sighting positions of common minke whale schools in the Sea of Japan and the Sea of Okhotsk in 2007.

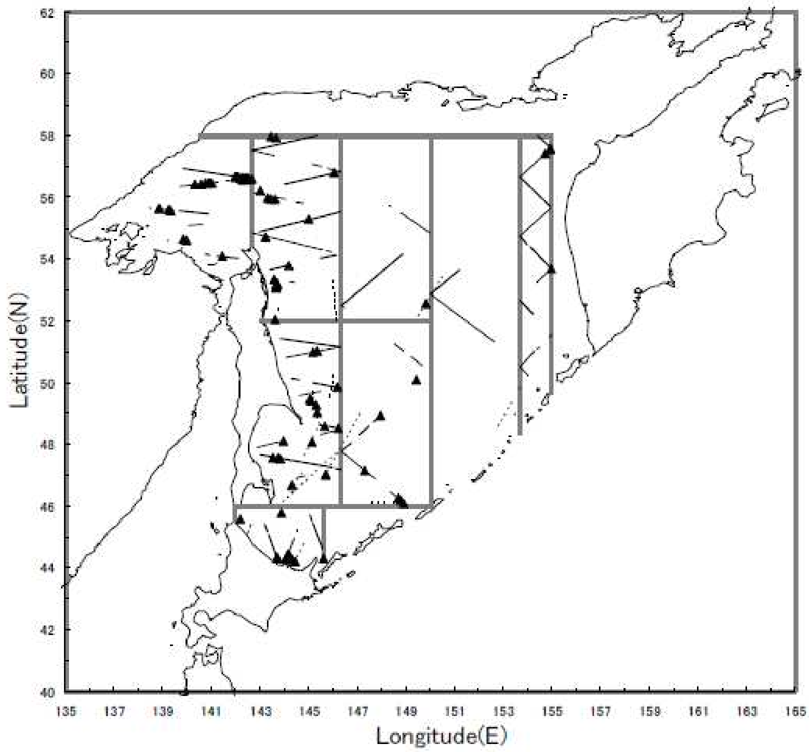

Fig. 36. Track line traversed on effort and sighting positions of common minke whale schools in the Sea of Okhotsk in 2003.

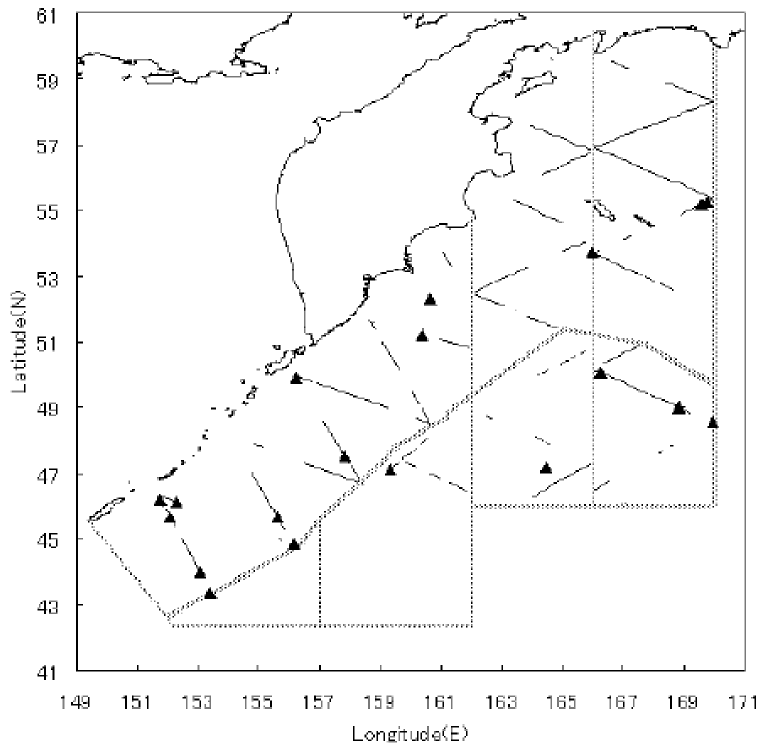

Fig. 37. Track line traversed on effort and sighting positions of common minke whale schools in the waters east of the Kuril archipelago and the Kamchatka peninsula in 2005.

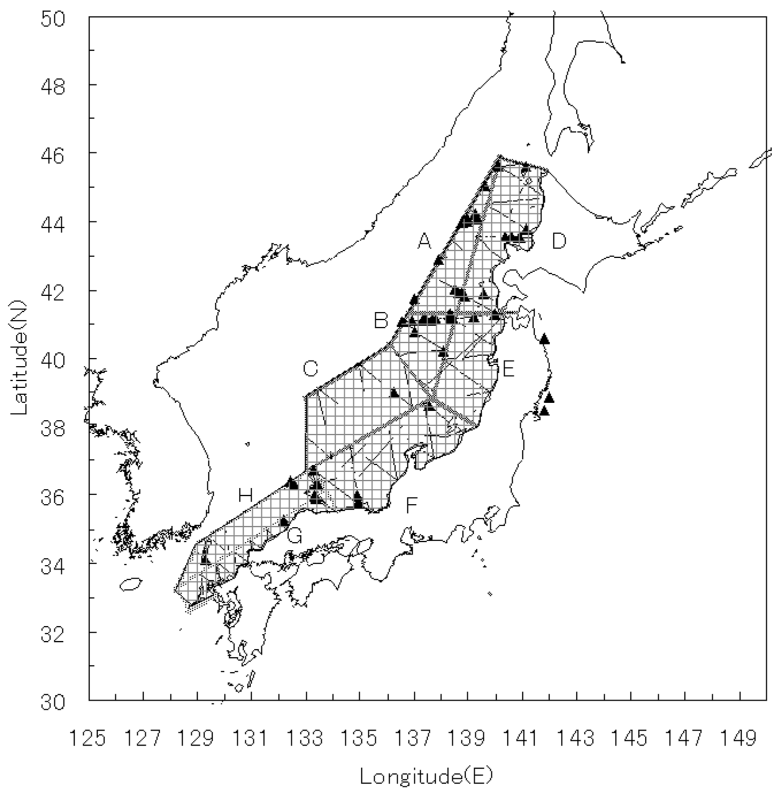

Fig. 38. Blocks used for abundance estimate in 2002.

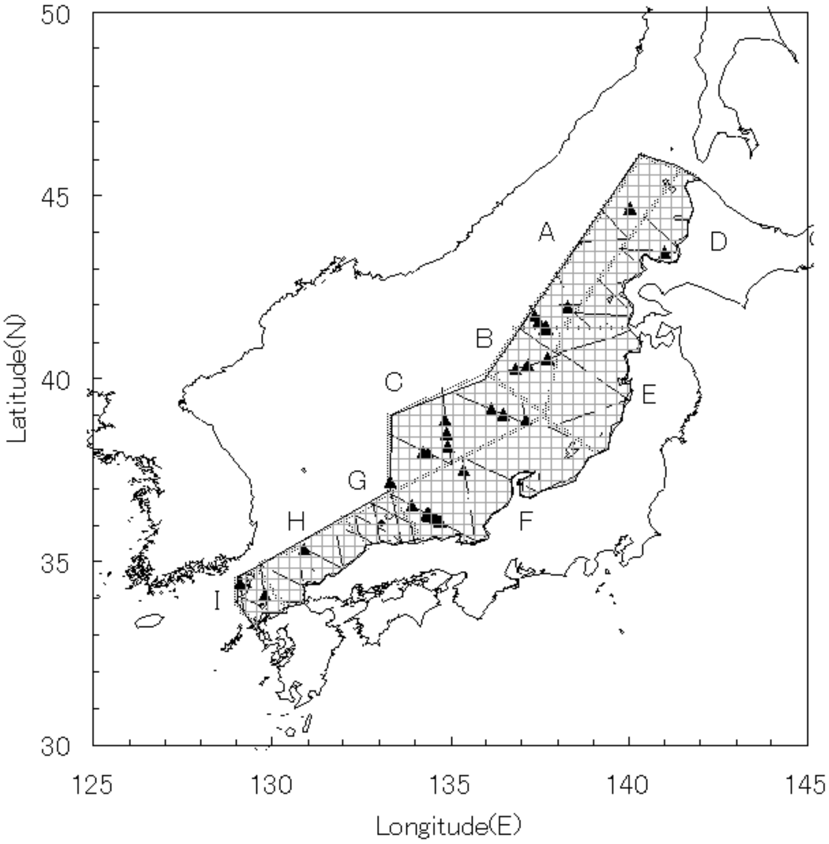

Fig. 39. Blocks used for abundance estimates in 2003.

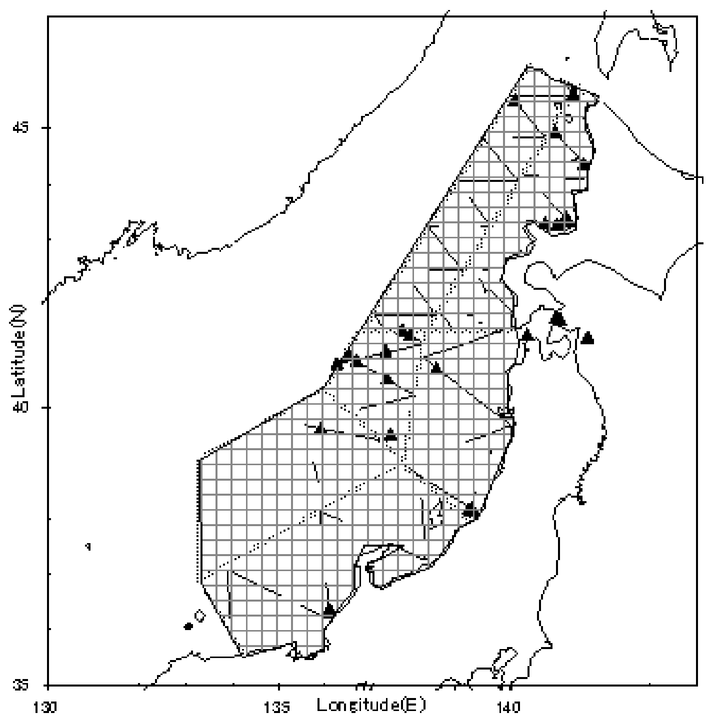

Fig. 40. Blocks used for abundance estimates in 2004.

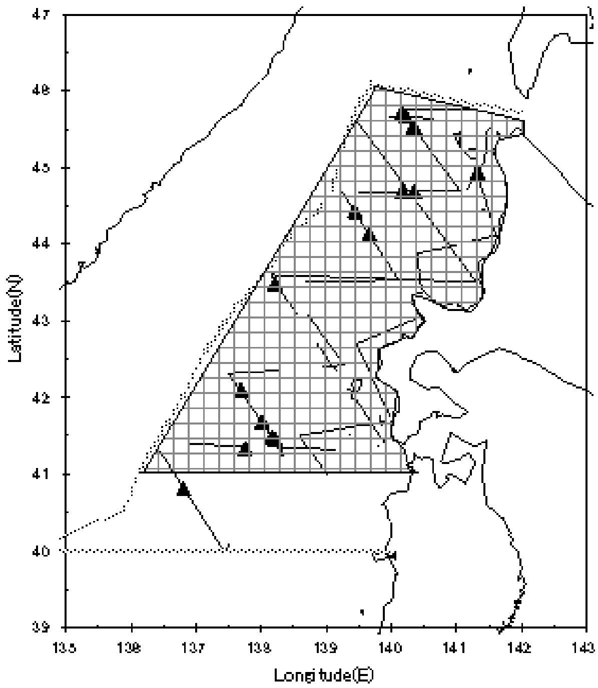

Fig. 41. Blocks used for abundance estimates in 2005.

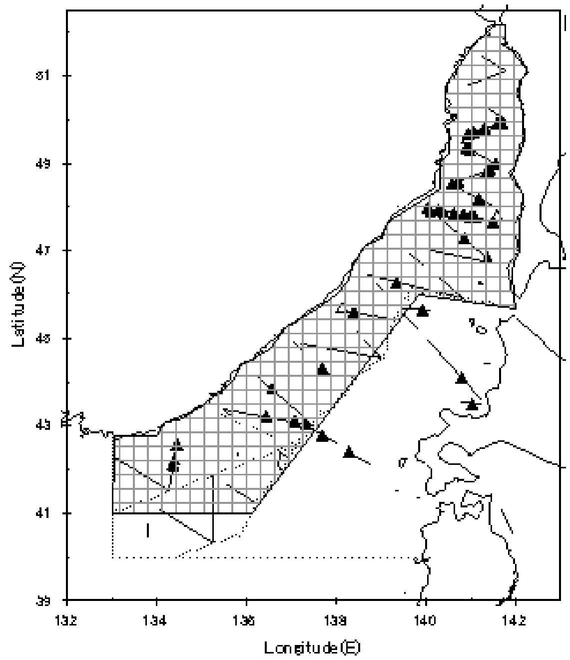

Fig. 42. Blocks used for abundance estimates in 2006.

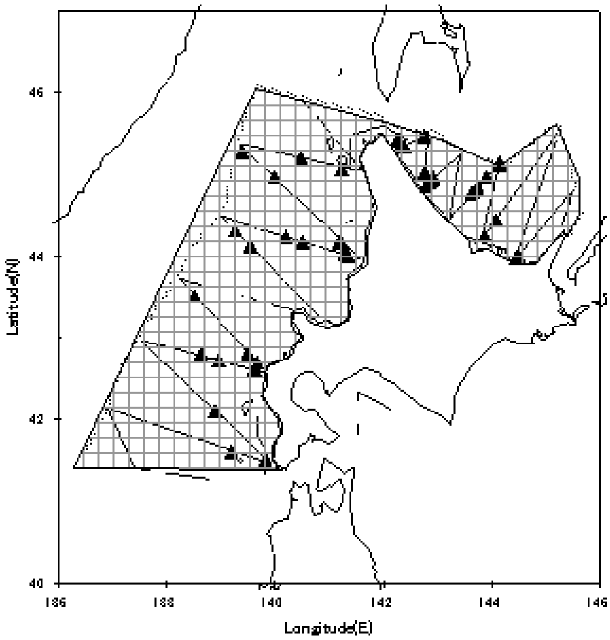

Fig. 43. Blocks used for abundance estimates in 2007.

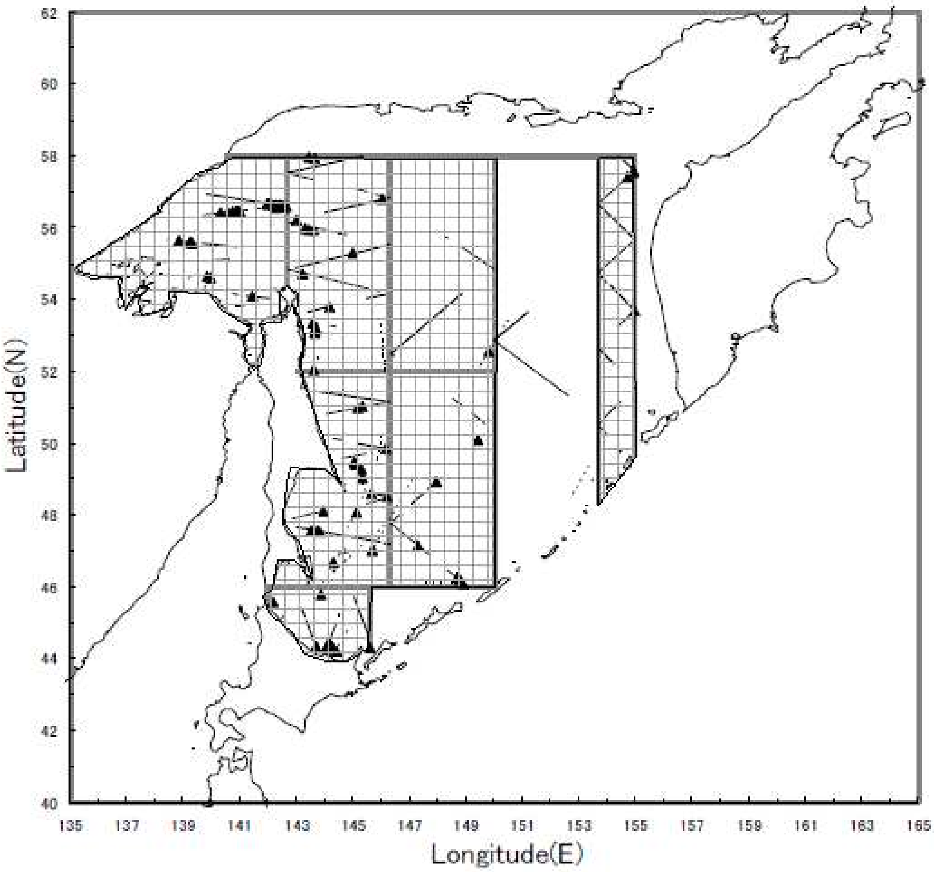

Fig. 44. Blocks used for abundance estimates in the Sea of Okhotsk in 2003.

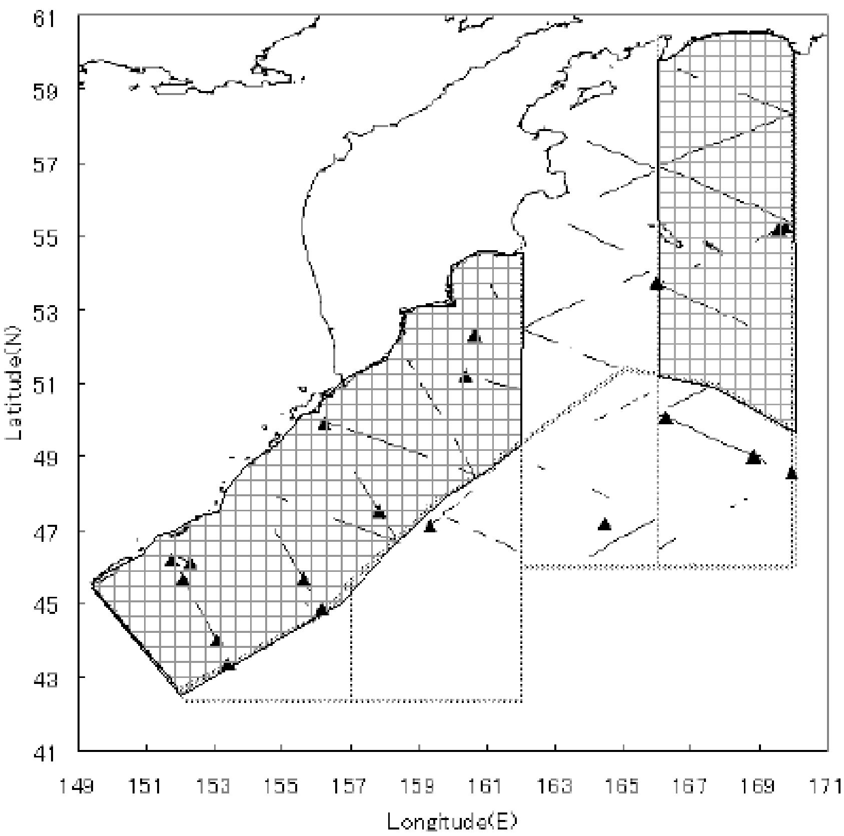

Fig. 45. Blocks used for abundance estimates in the waters east of the Kuril archipelago and the Kamchatka peninsula in 2005.

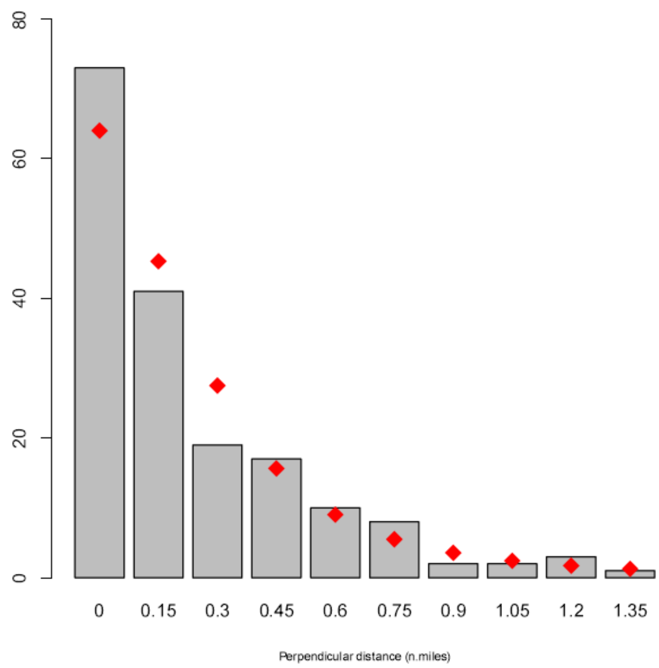

Fig. 46. Perpendicular distance distribution and the fitness of detection curve for the abundance estimate in the Sea of Japan (sub-areas 6 and 10).

Square shows the values of the best fit (Hazard rate model) to the observed values (bars).

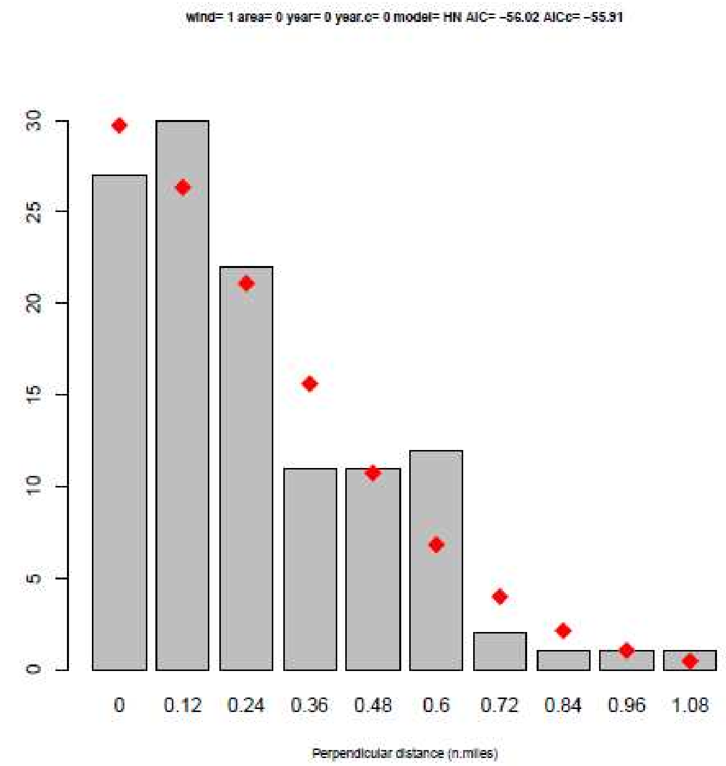

Fig. 47. Perpendicular distance distribution and the fitness of detection curve for the abundance estimate using top-barrel and the upper bridge sighting during the IO mode surveys in the Sea of Okhotsk and the Russian 200 n.miles EEZ east of the Kuril archipelago and the Kamchatka peninsula.

Square shows the values of the best fit (Half normal model) to the observed values (bars).

Table 1. Information on the Japanese dedicated sighting surveys for common minke whale abundance estimate.

No.	Season	Period[1]	Vessel[2]	Survey Mode[3]	Searching distance (nmi)	No. sighting (sch. – ani.) Pri.	Sec.	Area
Sea of Japan								
1	2002	10 April – 9 May	*KSK*	NCL	441.9	5–7	2–2	6ES
2		13 May – 1 July	*SM2*	NCL	2,175.0	33–34	2–2	6EN, 10E
3	2003	11 April – 10 May	*KSK*	NCL	708.0	3–3	–	6ES
4		12 May – 30 June	*SM2*	NCL	1,847.5	27–31	5–5	6EN, 10E
5	2004	11 May – 29 June	*SM2*	NCL	1,804.4	14–14	11–13	6EN, 10E
6	2005	12 May – 30 June	*SM2*	NCL	1,520.1	11 –12	6 – 6	10E
7	2006	18 May – 28 June	*KKM*	IO	1,852.2	51 – 55	6 – 6	10W, 10E
8	2007	18 May – 28 June	*SM2*	IO	1,598.7	39 – 47	6 – 6	10E, 11
Sea of Okhotsk								
9	2003	22 July – 19 Sep.	*SM1*	IO, IOA	893.9	12 – 12	5 – 6	12E
10		22 July – 19 Sep.	*SM2*	IO, IOA	1,804.3	69 – 78	16 – 18	11, 12W
Pacific (Russian EEZ east of the Kuril archipelago and the Kamchatka peninsula)								
11	2005	29 July – 20 Sep.	*SM1*	IO	1,441.2	5 – 5	6 – 6	9
12		29 July – 20 Sep.	*SM2*	IO	928.9	6 – 6	9 – 9	8, 9, 12

1: the period including the transit,
2: KSK: *Kurosaki*, KKM; *Kaiko-maru*, SM1; *Shonan-maru*, SM2: *Shonan-maru No.2*
3. NCL; normal closing mode, IO: IO passing mode, IOA; IO abeam closing mode.

Table 2. Model and covariate to estimate the abundance according to AIC for the abundance estimate in the Sea of Japan. 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 3. Abundance estimate of J-stock common minke whales in the Sea of Japan using the Japanese dedicated sighting survey data by normal closing mode.

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
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

Table 4. Covariate and model selection by AIC for top barrel and upper bridge sightings during IO mode surveys.

Covariate	Model	AIC
wind	HN	-56.019
wind + year	HN	-54.856
wind + year	HR	-54.001
wind	HR	-53.423
wind + area + year	NN	-53.320

Table 5. Results of abundance estimate by block using the sightings by top-barrel and upper-bridge during IO mode survey.

Year	Sub-area	Block	Area size (n.m.^{2})	Research ditance (n.m.)	No. sightings	Mean school size	ESW	Abundance	Density	CV
2003	11	11W	15,243	191.8	10	1.11017	0.5003	882	0.0578	0.826
2003	12NE	CE	110,770	456.3	3	1.11017	0.5003	808	0.0073	0.709
2003	12NE	CNW	149,213	616.0	1	1.11017	0.5003	269	0.0018	0.924
2003	12SW,12NE	CSW	155,305	547.1	6	1.11017	0.5003	1,890	0.0122	0.405
2003	12SW,12NE	OSW	194,272	224.8	3	1.11017	0.5003	2,876	0.0148	0.627
2003	12NE	SHA	156,762	312.1	18	1.11017	0.4860	10,625	0.0678	0.353
2005	9, 9N	BEN	74,303	578.1	2	1.11017	0.5003	285	0.0038	1.688
2005	9	BES	65,401	259.5	1	1.11017	0.5003	280	0.0043	0.628
2005	8, 9, 9N	KUL	137,519	895.3	5	1.11017	0.5003	852	0.0062	0.513
2006	10W	RCM	36,496	776.1	17	1.11017	0.4699	999	0.0274	0.494
2006	10W	RCN	14,206	252.5	17	1.11017	0.4851	1,128	0.0794	0.442
2006	10W	RCS	13,210	128.6	2	1.11017	0.3710	350	0.0265	0.927
2007	11	OS	9,064	564.0	19	1.11017	0.4731	377	0.0416	0.389
2007	10E	SJ	27,823	1051.4	14	1.11017	0.4819	442	0.0159	0.252

Table 6. Abundance estimate by sub-area.using Japanese dedicated sighitng survey data.

Sub-area	Year	Season	Mode	Areal coverage	Abundance	CV	Source
6E	2002	May-June	NCL	100.0	1,795	0.458	This study
	2003	May-June	NCL	100.0	1,059	0.322	This study
	2004	May-June	NCL	79.1	727	0.372	This study
8	1990	Aug-Sep	NCL	61.8	1,067	0.705	JCRM 6:124
9	1990	Aug-Sep	NCL	35.0	8,264	0.396	JCRM 6:124
9N	2005	Aug-Sep	IO	67.8	420	0.969	This study
10W	2006	May-June	IO	59.9	2,476	0.312	This study
10E	2002	May-June	NCL	100.0	816	0.658	This study
	2003	May-June	NCL	100.0	405	0.566	This study
	2004	May-June	NCL	100.0	474	0.537	This study
	2005	May-June	NCL	100.0	666	0.444	This study
11	1990	Aug-Sep	NCL	100.0	2,120	0.449	JCRM 6:124
	1999	Aug-Sep	IO	100.0	1,456	0.565	JCRM 6:124
	2003	Aug-Sep	IO, IOA	33.9	882	0.820	This study
	2007	Aug-Sep	IO	20.2	377	0.389	This study
12SW	1990	Aug-Sep	NCL	100.0	5,244	0.806	JCRM 6:124
	2003	Aug-Sep	IO, IOA	100.0	3,401	0.409	This study
12NE	1990	Aug-Sep	NCL	100.0	10,397	0.364	JCRM 6:124
	1999	Aug-Sep	NCL	89.4	11,544	0.380	JCRM 6:124
	2003	Aug-Sep	IO, IOA	46.0	13,067	0.287	This study