Abundance estimate of western North Pacific Bryde's whales for the estimation of additional variance and CLA application

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ABSTRACT

This paper presents the abundance estimates by survey block to finalize the abundance estimate with additional variance of western North Pacific Bryde's whales for the Catch Limit Algorithm application which is dealt in Kitakado et al. (2008). Two sets of abundance estimates from the recent sighting surveys (1998-2002) and the past ones (1988-1996) are obtained using the conventional line transect method assuming g(0)=1. During the recent period only, The surveys were conducted following the Guidelines Within the RMS and under oversight by SC. Due to the recommendations and suggestions from the last 59th SC, cut-off of the area with biased efforts, and modification of sampling units were conducted. For the recent period, the sighting data was stratified by sub-area. The effective search half width (*esw*) was estimated using hazard-rate probability model without adjustment terms. The *esw* and the mean school size stratified by sub-area were selected as the best case with minimum AIC and Bonferroni's multiple t-tests respectively. It is necessary to estimate an additional variance to estimate abundance in each sub-area because the surveys were conducted in multi-year and covered in part of management area in each year. The abundance in the past survey (1988-1996) was estimated to compare with the recent one to estimate the additional variances.

KEYWORDS: BRYDE'S WHALE; NORTHERN HEMISPHERE; PACIFIC OCEAN

INTRODUCTION

In 1995, the Scientific Committee had conducted the Comprehensive Assessment process for North Pacific Bryde's whales from 1995 to 1996. The abundance of western North Pacific Bryde's whales was estimated based on the sighting data collected from 1988 to 1995 (Shimada and Miyashita 1996). The Committee agreed that the estimates would not be appropriate for implementation of the RMP, because it did not take account of the heterogeneities of data collected by different four type vessels and over nine years. However, the Committee agreed that the estimates would be adequate for use in Implementation Simulation Trials. In 1997, the abundance estimate was updated using the sighting data between 1988 and 1996 including two surveys (Shimada and Miyashita 1997).

The Scientific Committee set the management area consisted of two sub-areas in 1998 (Anon, 1999). A new survey was proposed in Scientific Committee meeting in 1997, and it aimed at providing abundance estimates for the western Bryde's whales to use in implementing the RMP. During the 1998 Scientific Committee, Miyashita presented the four years sighting survey plan in the North Pacific Sightings Survey Steering Group (Miyashita and Shimada, 1998). It was clarified that the data collected were intended for use in both implementation simulation trials and implementation of the RMP for North Pacific Bryde's whales. The Committee noted that Shimada would participate in the survey and agreed that he is an appropriate scientist as oversight by the Scientific Committee.

The survey project was begun in summer, 1998. Though the survey planned using two vessels, only one vessel was able to use for this project in 2000 (Shimada and Miyashita, 2001). The period of project was extended to five years. Sub-area 1 was covered completely for four years from 1998 to 2001. Sub-area 2 was covered for one year in 2002 (Shimada 2003).

Documents of plan and report were submitted to the Scientific Committee before and after each cruise (Miyashita and Shimada 1998, Shimada 1999, 2000, 2001, 2002, 2003, Shimada and Miyashita 1999, 2000, 2001, 2002). They were confirmed to have followed the RMS guide line. The summary cruise report, the above documents and data provided to the IWC Secretariat on 28 December 2003 no later than six months prior to the meeting of SC in which data from the survey are to be used as input CLA under the Requirements and Guidelines for Conducting Surveys and Analysing Data Within the RMS (Anon, 2005)

To provide advice to the Scientific Committee on whether to proceed to Implementation Trials for western North Pacific Bryde's whales, the Intercessional Workshop on the pre-Implementation Assessment was held at Tokyo, 21-24 March 2005. The workshop agreed the abundance estimates in Shimada (2004) from the surveys conducted from 1998 to 2002 should be used for conditioning, and also identified the necessity of the estimation of the additional variances (Anon, 2005). For this purpose, 13 blocks defined in 1998-2002 surveys divide the management area (sub-Area 1 and 2, see Fig. 1)

Though the abundance estimates for use in the CLA were presented in the Scientific Committee (Shimada *et al.*, 2007) in Anchorage in 2007, the Committee agreed that it was not possible to make a recommendation regarding the use of them because the results had to be provided to the Secretariat and circulated to the Committee no later than three months before the meeting. In addition, more detailed documentation of survey plans were required

for considering whether abundance estimates from surveys can be used for input to the CLA. The Committee developed a list of the minimum information that it would normally expect to receive when reviewing abundance estimates for use in the CLA and recommends that the 'Requirements and Guidelines for Conducting Surveys and Analysing data within the Revised Management Scheme' be updated. Specific suggestions as to Shimada *et al*. (2007) are given by the Committee in Anon (2007).

This paper with careful consideration to these is submitted to the Secretariat and circulates to the Committee no later than three months before the Santiago meeting, 2008.

MATERIALS AND METHODS

The abundance of the western North Pacific Bryde's whales was examined using sighting data obtained in the dedicated sighting surveys from 1998 to 2002.recent. The estimates from 1988-1996 surveys were also used for the estimation of the additional variance. Details of operation, sighting procedure, data and abundance estimation procedure for these surveys are as follows.

The recent surveys from 1998 to 2002

Operation

The vessels followed the predetermined track lines at a speed of 11.5 knots. Sighting efforts continued from 30 minutes after sunrise to 30 minutes before sunset, but were only carried out when wind force was below the Beaufort wind scale five and meteorological visibility was over 2 n. miles (Miyashita, 1993).

Block and cruise tracks

During the recent sighting surveys conducted in the sub-area 1W from 130°E to 165°E and from 10°N to 43°N, in the sub-area 1E from 165°E to 180° and from 10°N to 43°N and in the sub-area 2 from 180° to 155°W and from 25°N to 43°N, all sightings of Bryde's whales occurred in the waters east of 137°E and west of 157°W, south of 41°N and north of 12°N. Survey blocks were defined as 1WW-M, 1WW-L, 1WM-H, 1WM-M, 1WM-L, 1WE-H, 1WE-M and 1WE-L in the sub-area 1W, 1E-H, 1E-M and 1E-L in the sub-area 1E and 2-H and 2-M in the sub-area 2 (Fig. 1).

The surveys used a line transect method and cruised along predetermined track line arranged systematically as described in Miyashita and Shimada (1998). Track lines planned in the surveys are illustrated in Fig. 2. They were conducted in August and September each year.

The whole management area was covered through these surveys (Fig.3). But It was covered less than 50 % in the northern parts (north of 39°N) of 1E-H and 2-H block during the recent surveys. Because then conditions in the blocks had not satisfied standards of visibility or sight ability of sighting survey, we could not conduct sighting survey and steamed off effort after waiting there so far as time permits. No sightings of Bryde's whales were in those northern parts. Areas in both reset blocks were 66% and 52% of the original blocks in 1E-H and 2-H respectively. After the northern boundaries reset to 39°N in the both blocks, the sighting rates (n/L) estimated in the both blocks excluding the parts north of 39°N. The sighting rates (CV %) before and after the reset were 0.029 (55.65%) and 0.026 (61.01%) in 1E-H block, and 0.009 (49.96%) and 0.007 (56.31%) in 2-H block respectively. When it was compared with the n/L estimated, it was no significant difference. In the past surveys, both blocks were adequately covered (Fig.4). As the densities of distribution of the Bryde's whales in the northern part (north of 39°N) were compared with them in the southern part. 0 or one sighting of the Bryde's whale in the northern part in each 1E-H and 2-H block in each surveyed year. Ratio of density of whales in the northern part to one in the southern part was from 0 to 0.55 and from 0 to 0.08 in each surveyed year in each block. The densities in the north of 39°N were lower clearly than other side. Then the northern boundaries reset to 39°N in the both blocks in the past surveys as well as the recent surveys. Both 1E-H and 2-H blocks were used same definitions of boundaries on this study. Coverage of each block and each mode was over 60% excluding any no sighting blocks after the reset as shown in Table 5a and 5b. The coverage of each block during abeam closing mode was good almost over 80%.

Survey modes

The original plan was proposed to the Scientific Committee surveys using the normal closing mode and the normal passing mode (Miyashita and Shimada, 1998). But all sightings like Bryde's whales were approached in not only the normal closing mode but also passing mode when the vessel passed abeam of the first sighting position, because it was necessary to check three prominent ridges on the rostrum in order to identify Bryde's whales. It was described in the cruise reports (Shimada 1999, 2000, 2001, 2002, 2003) and the research plans (Shimada and Miyashita 1999, 2000, 2001, 2002) and submitted to the Committee to adapt this mode to confirm the Bryde's whales. This sighting mode is called an abeam closing mode. When large baleen whales including like Bryde's whales were sighted in the abeam closing mode, the vessel left track line and approached to confirm the species to the extent possible, after the vessel passed abeam of the first sighting position. After the confirmation, the vessels returned to the left point on track lines. Therefore this mode did not skip pre-determined survey effort as passing mode. And also when other species were sighted in this mode, they were passed like normal passing mode. On the other hand, when the normal closing mode was employed, all schools of cetaceans were approached off survey effort to confirm species and to estimate school size in the research area.

The species and school size were confirmed correctly in both modes. The sighting mode in the research area alternately adopted normal closing mode and abeam closing mode.

SCANS mode survey was conducted in 1WE-L (Fig. 2) in 1998 (Shimada, 1999). It was used on this study as the abeam passing mode.

Survey vessels

Data used in the recent study were obtained from eleven cetacean sighting cruises using four research vessels equipped top barrel (Table 1a) in the North Pacific in August and September from 1998 to 2002.

The project covered in the 1WE-H, 1WE-M and 1W-L block in 1998 using four vessels (*Toshimaru* No.11, *Kyomaru* No.1, *Kyoshinmaru* No.2 and *Shonanmaru* No.2). It covered the blocks of 1WM-H, 1WM-M and 1W-L in 2000 using one vessel (*Toshimaru* No.11). The blocks of 1WW-M and 1WW-L were covered using one vessel (*Kyomaru* No.1) in 2001. Sub-area 1W was covered completely for three years from 1998, 2000 and 2001. Sub-area 1E was covered in 1999 using three vessels (*Toshimaru* No.11, *Kyomaru* No.1 and *Kyoshinmaru* No.2). Sub-area 2 was covered in 2002 using two vessels (*Shonanmaru* and *Shonanmaru* No.2). Specifications of research vessels are shown in Table 1a.

Sighting procedure

Two observers were stationed in the top barrel, and a helmsman, the captain, an engineer, and at least one researcher on the upper or front bridge. An officer in the bridge was responsible for recording sighting efforts and weather conditions. It was not that a newcomer and a pair of beginners of cetacean sightings as primary observer took part in a platform on top barrel in order to escape some problems of their sighting behaviour (Mori *et.al* 2003).

Primary observers used binoculars with reticle to estimate a radial distance with accuracy. The sighting angle from the vessel to the cetaceans was estimated using angle boards at the first attempt. All vessels have equipped a top barrel with angle board. Plots of distribution of the radial distances and angles are shown in Fig. 7.

Distance and angle experiments

On-board training to maintain accuracy of estimation of sighting angle and distance was conducted prior to the sighting surveys in the research area. Tests to examine angle and distance estimation were conducted midway on all vessels. This experiment was designed to examine the precision and accuracy of distance and angle estimates to a sighting. A buoy with a radar-reflecting board was used as the sighting target and distance and angle estimates were made by the primary observers while the ship was steaming. At pre-determined distances from 0.01 to 3.0 nautical miles and angles from the buoy from 0 to 60 degree, visual observations by the primary observers were taken simultaneously with radar readings. Each platform was scheduled with ten trials per observer. Primary observers were tested from platforms where they normally conducted sighting effort and used the same procedures and equipment used in their normal sighting procedures.

IWC oversight

Shimada was nominated as the overseeing personnel each cruise (Anon., 1998, 1999, 2000, 2001 and 2002). He boarded research vessels excluding the 1999 survey. Pastene and Nishiwaki (the Institute of Cetacean Research) were approved as overseeing scientists, and the former boarded a research vessel in the first half of the 1999 cruise, and the latter in the second. They confirmed daily progress of the other vessel by radio communication for all cruises. All cruises during this survey period had been subject to oversight by IWC Scientific Committee.

Sighting data

Total research distances under the normal closing modes and the abeam closing mode were 10,634 and 12,075 nautical miles, respectively after a cut off the northern parts of blocks which could not cover enough. Total primary sightings of Bryde's whales were 101 schools with 136 animals under the normal closing mode and 150 schools with 190 animals under the abeam closing mode, after truncation and the cut off (Fig. 3). all sightings of Bryde's whales occurred in the waters east of 137°E and west of 157°W, south of 41°N and north of 12°N (Fig. 3)

Like Bryde's whales

During the abeam closing mode, using data before truncation of the abundance estimation, initial like Bryde's sightings in the middle and low latitudinal blocks to the south of the summer distribution of sei whales were closed on separated into 86% of sightings confirmed to be Bryde's whales, 14% of sightings could not be identified species. In the high latitudinal blocks (1WE-H, 1E-H and 2-H) where are in the summer distribution area of sei whales, initial like Bryde's sightings were closed on separated into 73% of sightings confirmed to be Bryde's whales, 8% were not Bryde's whales (confirmed sei whales), and 19% could not be identify species (Table 2). On the other hand, during normal closing mode, initial sightings were not judged whether like Bryde's whales or not, because all sightings were automatically turned off into them.

The past surveys from 1988 to 1996

Shimada and Miyashita (1997) described the detail of operation, sighting procedure for 1988-1996 surveys.

Operation

The past surveys were conducted in the line transect surveys in August and September from 1988 to 1996. Track lines used in the surveys and sighting positions of the Bryde's whales are illustrated in Fig. 4 and Fig. 5 respectively. As shown in the figure, the whole management area was covered through the surveys period. Some vessels (*Toshimaru No.11*, *No.15*, *No.18*, *No.25*, *Shonanmaru No.2*, *Kyomaru No.1* and *Kyoshinmaru No.2*) followed the predetermined track lines at a speed of 11.5 knots. Others (*Hoyomaru No.12*, *Shinhoyomaru*, *Kaishomaru*, *and Shunyomaru*) steamed at a speed of 10 knots. Sighting efforts continued from 30 minutes after sunrise to 30 minutes before sunset, but were carried out when wind force was below the Beaufort wind scale five and meteorological visibility was over 2 n. miles (Miyashita, 1993). That generally operational manner was same as the recent surveys.

Block and cruise tracks

Though the surveys used line transect method and cruised along predetermined track line arranged systematically each year (Fig. 6a to 6i), the purpose of surveys was different each year and not always for the Bryde's whale's abundance estimate.

Survey modes

The surveys used the normal closing mode only, with the exception survey under the normal passing mode on *Shonanmaru No.2* in 1993 conducted in 200 n. miles EEZ of foreign countries in 1WW-L, 1WE-L and 1E-L blocks, along predetermined track line arranged systematically in the research area. Effort data on passing mode during transit between home port and research area was excluded from this estimation without the transit from 1988 to 1990 because of no distinction of mode in original data.

Total research distances under the normal closing modes were 57,045 nautical miles including 2,798 nautical miles for the normal passing mode after a cut off the northern parts of blocks which could not cover enough.

Survey vessels

Data used in the past study were obtained from 37 cetacean sighting cruises using nine research vessels. Seven vessels were equipped top barrel and three vessels were not having that (Table 1a and 1b). *Shunyomaru* has equipped a top barrel in 1994.

Sighting procedure

Two observers were stationed in the top barrel, and a helmsman, the captain, an engineer, and at least one researcher on the upper or front bridge on the research vessels with top barrel as *Toshimaru No.11*, *No.15*, *No.18*, *No.25*, *Shonanmaru No.2*, *Kyomaru No.1*, *Kyoshinmaru No.2*, and *Shunyomaru* (in 1995 and 1996). At least a single observer and a researcher were stationed on the upper bridge on them without top barrel as *Hoyomaru No.12*, *Shinhoyomaru*, *Kaishomaru*, *and Shunyomaru*. An officer in the bridge was responsible for recording sighting efforts and weather conditions.

It was not that binoculars with reticle and angle boards were equipped on all vessels (Table 1a and 1b). Seven to 12 vessels and 21 to 37 cruises were used binoculars without reticle. Plots of distribution of the radial distances and angles are shown in Fig. 7. Distribution in histogram of radial distance in the recent surveys were difference from it in the past surveys, because five vessels and 13 cruises were not have top barrel and eye levels of platform (10 m from sea surface) were lower than others. Sighting behaviours for angle were not difference between the surveys. influence of vessel type in the detection function was low as a result of AIC.

Distance and angle experiments

On-board training to maintain accuracy of estimation of sighting angle and distance was conducted prior to the sighting surveys in the research area. Tests to examine angle and distance estimation were conducted midway on some vessels equipped a buoy with a radar-reflecting board. Among 25 cruises which made sightings of Bryde's whales, 14 cruises conducted the experiments.

Sighting data

The sighting data was used in August and September only. The species and school size were confirmed correctly in the normal closing mode. Total research distances were 57,045 nautical miles after a cut off the northern parts of blocks which could not cover enough. The effort data was arranged at each cell of 1° latitude $\times$ 1° longitude as a sampling unit, because different type of vessels and purposes of survey had overlapped in each block.

It was difficult to obtain the leg-based variance of encounter rate since the blocks in the recent surveys did not correspond to those in the past surveys. During the past sighting surveys conducted over the sub-area 1W, 1E and 2, all sightings of Bryde's whales occurred in the waters east of 130°E and west of 157°W, south of 43°N and north of 2°N (Fig. 5). Total primary sightings of Bryde's whales were 355 schools with 520 animals, after truncation and cut off the northern parts.

Abundance estimation procedure

Abundances by block and year were estimated separately in the recent and past surveys

Data from the distance and angle experiment on the recent sighting survey were analysed using the methodology of Butterworth, Best and Hembree (1984). Sighting radial distances and angles were corrected by each observer, platform and vessel using the result of the experiment when the observer estimations were significant difference from radar measurements. When significant bias (at the 5% level) was found using linear regression models with standard error proportional to true (radar) distance, it was possible to correct this bias in the usual way by dividing the estimated distances by the estimated slope of the regression through the origin. When significant bias for angle was found using linear regression models with constant variance, the bias was corrected by dividing all estimated angles by the estimated angles by the estimated slope of the regression through the origin. For sighting data on the past surveys, the sighting distances and angles were not corrected, because the test on board had conducted less than half of the cruises and the process had not refined on some cruises.

After perpendicular distance was calculated from the sighting radial distance and angle to object, it was truncated at 3.0 n. miles and grouped into 10. The population size of Bryde's whales was estimated using the program DISTANCE ver. 5.0 release 2 (Thomas *et al.* 2006). Abundance (N_i) in the *i*-th block was estimated by the following formula by Burnham, Anderson and Laake (1980);

$$\hat{N}_i = \frac{n_i \cdot f_i(0) \cdot s_i \cdot A_i}{2 \cdot L_i},$$

$$\mathrm{var}\left(\hat{N}_i\right) = \hat{N}_i^{\,2} \cdot \left\{ \frac{\mathrm{var}(n_i)}{n_i^{\,2}} + \frac{\mathrm{var}\left(f_i(0)\right)}{\left(f_i(0)\right)^2} + \frac{\mathrm{var}(s_i)}{s_i^{\,2}} \right\},$$

where n_i is the number of sightings in the *i*-th block,

$f_i(0)$ is the probability density of perpendicular distances evaluated at zero,

s_i is the expected school size in the *i*-th block,

L_i is the distance covered by the vessel while on effort in the *i*-th block,

A_i is the area in the *i*-th block containing the population size of N_i animals.

Sighting data were stratified to estimate the detection probability and the expected mean school size.

Effective search half width (*esw*) was calculated using a hazard-rate model without the adjustment terms. Though estimation of the *esw* was tried using the program DISTACE, their estimations with covariates did not convergence. Hence sighting data was stratified by research mode (abeam closing mode and normal closing), vessel's type (place of top barrel; on the fore mast and on the main mast), Beaufort wind scale categorized two levels (0-2/3-5 in the recent surveys and 0-4/5 in the past surveys) and sub-area. The significant factors were examined using Akaike's information criterion (AIC) (Table 3a and 3b).

Model: Hazard Rate key function, $$g(x) = 1 - \exp\left\{ -\left[\frac{x}{\sigma} \right] \right\}^{-b}$$

The mean school size was estimated as constant and different over sub-area. The size bias was corrected by the regression of log (school size) on the detection probability with significance level at 0.15 (Buckland *et al.*, 1993).

The variance of the number of schools sighed in each block is estimated based on the sighting data on the replicate line (one segment between way points) for the recent surveys and one cell at 1° latitude × 1° longitude for the past surveys by the following formula:

$$n_i = \sum_{j=1}^{k_i} n_{ij},$$

$$\mathrm{var}(n_i) = \frac{L_i \cdot \sum_{j=1}^{k_i} \left\{ l_{ij} \cdot \left(\frac{n_{ij}}{l_{ij}} - \frac{n_i}{l_i} \right)^2 \right\}}{k_i - 1},$$

where *j* is the j th replicate line or cell in each block, and

$$L_i = \sum_{j=i}^{k_i} l_{ij} \ ,$$

k_i is the number of surveyed one segment or cell in i th line.

When there was only one replicate line for the block, the CV(n/L) was not calculated from an inter-transect-variation. Assuming the Poisson-like variation for the sightings, $CV^2(n/L)_i$ is proportional to $1/L_i$. Therefore the CV of the block with only one replicate line was calculated by κ / L_i, where L_i was the effort of the block andcalibration factor μ is used

$$\kappa = \sum_{j=1}^{J} \frac{L_j \times \mathrm{CV}^2 (\mathrm{n/L})_j}{J}$$

where j = 1, ..., J was the index of the blocks with more than one replicate line.

For the past surveys during 1988 to 1996, CV(n/L) was calculated by using the cells of 1 degree by 1 degree (1×1 cells) as the sampling units because of difficulty on the calculation of leg-based variance. To make two CV(n/L)s between the past and recent surveys comparable for the estimation of unbiased additional variance, we used a calibration factor γ, which was calculated by the following method: let $CV^{leg}(n/L)_i$ and $CV^{1deg}(n/L)_i$ denote the leg-based and 1 degree-based CV of n/L of the i th block calculated from the recent survey data (Table 6). From Table 6, the sample size of sightings tends to affect the calibration factor. We therefore carry out the following linear regression:

$$\log\{CV^{leg}(n/L)_i\} = \log\{CV^{1\deg}(n/L)_i\} + a + b\log(n_i) + \varepsilon$$

where $\log\{CV^{1\deg}(n/L)_i\}$ is an offset term, $\log(n_i)$ is the logarithm of sample size in the i th block, a and b are the parameters to be estimated, and ε is a normal deviate which has a normal distribution, $N(0,\sigma^2)$. Then the calibration factor as a function of sample size is given by

$$\gamma(n_i) = \exp(\hat{a} + \hat{b}\log(n_i) + \hat{\sigma}^2/2)$$

and the corrected CV of the i th block in the past surveys, $CV^{cor}(n/L)_i$, is calculated by multiplying the 1×1 cell-based CV, $CV^{1\times1}(n/L)_i$, by the calibration factor, $\gamma(n_i)$, where n_i is the sample size of the i th block in the past surveys.

RESULTS AND DISCUSSION

Abundance estimate for the recent surveys from 1998 to 2002

Detection probability

As a result of test using AIC (Table 3a), the stratified model by sub-area was selected as minimum AIC from them. The value of f(0) was estimated as 0.5980 (CV=8.16%), 0.5343 (CV=9.82%) and 0.8497 (CV=24.66%) in sub-area 1W, 1E and 2 respectively. The *esw* then became 1.672, 1.872 and 1.177 n. miles respectively. The f(0) was estimated 0.5575 (CV=6.31%) under no stratification and constant of all factors as the second minimum AIC. The *esw* then became 1.794 n. miles. Though it was no significant difference among them, the *esw* stratified by sub-area indicated the minimum AIC was used in this abundance estimation as a base case. The sighting data was grouped to estimate the *esw*. There was no conspicuous spike at 0 n. miles from track line as a plot of the detection probability without smearing. When all of sightings were smeared the estimation of abundance and the *esw* was estimated, there is no significant difference between the two. Hence, we adopted the result without smearing. Histograms of perpendicular distances and plot of detection probability are shown in Fig. 8a and 8b. Smearing did not used to keep consistency, because the distance and angle experiments had not conducted on all cruises in the past surveys

School sizes

The school sizes ranged from one to four, and 95% of the sightings are the sightings of one or two (Fig. 9a). It was no significant difference each block. As school sizes of the Bryde's whale sighting were confirmed not only in normal closing mode but also in abeam closing mode. All sighting data were stratified to estimate mean school sizes by mode and sub-area. The school sizes were estimated as shown in Table 4a. The school sizes in sub-area 1W were significant different and corrected by the regression model. The mean school sizes in each factor of mode, sub-area and mode × sub-area were assessed using multiple comparisons by the Bonferroni test (Table 4b). Combinations including 1W and 1E were significant difference. Therefore the mean school sizes over blocks stratified by sub-area were used as base case. The estimated mean school size in sub-area 1W, 1E

and 2 was 1.14 (CV=3.66%), 1.33 (CV=3.60%) and 1.45 (CV=9.33%) respectively. The mean school size estimated 1.30 (CV=2.83%) under no stratification and constant of all factors as reference case.

Sighting rate

Number of segment was only one during the both mode in 1E-L block. The CVs of encounter rate were 110.20% and 62.80% in the abeam passing mode and the normal closing mode respectively as a result of the calibration.

Abundance by survey block

esw and the constant mean school size stratified by sub-area were consequently selected as base case.

The abundance and population densities by block and mode for the CLA of RMP were estimated for the base case and other reference cases. The parameters of abundance estimation are summarized for the base case in Table 5a and 5b, and for the reference case under no stratification and constant of all factors for esw and mean school size in Table 5c and 5d.

Because the probability of detecting animals on the track line, g(0), was assumed to be one in this study, the population size might be underestimated. Though it is necessary to try an independent observer experiment to estimate g(0) in future, it is difficult to improve it because of low distribution density for the Bryde's whales.

Abundance estimate for the past surveys from 1988 to 1996

Survey mode

As compared density of whales in the normal passing mode survey in 1WE-L in 1993 with the normal closing mode survey in same block in different year, 1996, the densities (CV%) were 0.00433 (52.59%) in the passing mode and 0.00501 (34.75%) in the closing mode. It was no significant difference. they were included in same data set because of valuable data within the foreign EEZ.

Detection probability

Detection probabilities in the past surveys were estimated as same method as the recent one. As a result of test using AIC (Table 3b) the stratified model by sub-area was selected as minimum AIC from them. The value of f(0) was estimated as 0.7346 (CV=6.67%), 1.0969 (CV=13.16%) and 1.152 (CV=40.28%) in sub-area 1W, 1E and 2 respectively. The *esw* then became 1.361, 0.899 and 0.868 n. miles respectively. The f(0) was estimated at 0.8307 (CV=6.00%) under no stratification and constant of all factors as the second minimum AIC. The *esw* then became 1.204 n. miles. Though it was no significant difference among them, the *esw* stratified by sub-area indicated the minimum AIC was used in this abundance estimation as a base case. The sighting data was grouped to estimate the *esw* without smearing of the sighting data. Frequency histograms of perpendicular distances and plot of detection probability for stratified by sub-area as the base case and constant in the examination area as the reference case shows in Fig. 8c and 8d respectively.

School sizes

The school sizes ranged from one to four without a sighting of eight animals, and 93% of the sightings are the sightings of one or two (Fig. 9b). It was no significant difference each block. The school sizes in sub-area 1W and 1E were significant different and corrected by the regression of log (school size) on the detection probability (Table 4c).

All sighting data were stratified to estimate mean school sizes by sub-area. The mean school sizes by sub-area were made multiple comparisons using the Bonferroni test (Table 4d). Combination of 1W and 1E was significant difference as a result. Therefore the mean school sizes over blocks stratified by sub-area were used as base case. The estimated mean school size in sub-area 1W, 1E and 2 was 1.27 (CV=2.52%), 1.57 (CV=4.60%) and 1.39 (CV=7.19%) respectively. The mean school size estimated 1.42 (CV=2.28%) under no stratification and constant for sub-areas as reference case.

Sighting rate

The coefficients estimated in the linear regression for the calibration factor were $\hat{a} = -0.28$ and $\hat{b} = 0.19$. The variance $\hat{s}^2$ was 0.071. Using these estimates, the calculated calibration factors (Table 7) and the corrected CVs for each block in the past surveys were provided in Table 8a and 8b. The predicted line showed satisfactory fits (Fig. 10). The model selection by AIC indicated that the model with the influence of sample size was better than that without the influence of sample size (Δ AIC = 3.83). In addition, the hypothesis test whether b = 0 or not also rejected the null hypothesis (b = 0) at the significance level of 5%.

Abundance by block and year

esw and the constant mean school size stratified by sub-area were consequently selected as base case.

Population densities in each block were estimated for the base case and other reference cases. The parameters of abundance estimation are summarized for the base case and a model of constant of esw and mean school size as a reference case in Table 8a and 8b. The abundances and CVs of them by block and year in order to estimate the final abundance with additional variance of the Bryde's whales for CLA of RMP (Kitakado *et al.*, 2008) were shown for the past and recent surveys in Table 9a and 9b respectively.

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Table 1a. Detailed specifications of research vessels in the present surveys (1998-2002)

Research vessel	*Toshimaru* No.11 *(T11)*	*Kyomaru* No.1 *(KY1)*	*Kyoshinmaru* No.2 *(KS2)*	*Shonanmaru* *(SM1)*	*Shonanmaru* No.2 *(SM2)*
Length overall	68.37m	69.15m	69.5m	70.55 m	70.55 m
Gross tonnage	782 tons (int.)	812.08 tons	1,130 tons (int.)	1,012 tons (int.)	916.44 tons in 1998 1,013 tons (int.) in 2002
Engine power	2,547 kW	3,677 kW	1,544 kW	4,045 kW	4,045 kW
Binoculars with reticules	✓	✓	✓	✓	✓
Top barrel	on the fore mast	on the fore mast	on the main mast	on the main mast	on the main mast
Eye level (Top barrel / Upper	18m / 10m	18m / 10m	17.5m / 9m	20.5m / 12m	20.5m / 12m
Year	1996	1991 1993	1995 1996		1988 1989 1990 1991 1992 1993 1994 1995
	1998 1999 2000	1998 1999 2001	1998 1999	2002	1998 2002

Table 1b. Detailed specifications of research vessels in the former surveys (1988 - 1996) in addition to Table 1.

Research vessel	*Toshimaru* No.15 *(T15)*	*Toshimaru* No.18 *(T18)*	*Toshimaru* No.25 *(T25)*	*Hoyomaru* No.12	*Kaisyomaru*	*Shinhoyomaru*	*Shunyomaru*	*Kankimaru* No.38
Gross tonnage	700 tons	758.33 tons	739.92tons	284.23 tons	299.16 tons	495.5tons	393.44tons	392 tons
Engine power		3,500hp	3,600hp	1,000hp	1,000hp	1,300hp	2,600hp	710hp
Binoculars with reticules	None	✓	✓	None	None	None	None	None
Top barrel	on the fore mast	on the fore mast	on the fore mast	None	None	None	on the fore mast from 1994	None
Year	1988	1991 1993	1988 1989 1990 1991 1992 1993	1988	1989 1990	1988 1989 1990 1991 1992 1995	1991 1992 1993 1995 1996	1995

Table 2. During the abeam closing mode, initial like Bryde's sightings were closed on separated, confirmed to be Bryde's whales, other whales (sei whales) and could not be identified species.

Block	Like Bryde's whale	Confirmed Bryde's whale	No Bryde's whale Confirmed Sei whale	Could not confirm species
1WE-H	30	22	2	6
1E-H	46	34	4	8
1WM-H	0	0	0	0
2-H	9	6	1	2
1WE-M	15	12	0	3
1E-M	73	66	0	7
1WM-M	0	0	0	0
1WW-M	0	0	0	0
2-M	6	4	0	2
1WE-L	1	1	0	0
1E-L	2	1	0	1
1WM-L	3	2	0	1
1WW-L	2	2	0	0
Sub total of H	85	62	7	16
%	100%	73%	8%	19%
Sub total of Mand M and L	102	88	0	14
%	100%	86%	0%	14%
Total	187	150	7	30
%	100%	80%	4%	16%

Table 3a. For the recent surveys (1998-2002), effective search half widths (*esw*) were calculated using a hazard-rate model without the adjustments. Sighting data was stratified by research mode, vessel's type (place of top barrel), Beaufort wind scale and sub-area. They were tested using Akaike's information criterion (AIC).

Data	Mode	Vessel	Wind	Sub-area	n	LnL	ESW	CV% (ESW)	AIC	Sum(AIC)
98-02	All	All	All	All	251	-533.21	1.7936	6.31	1070.4	1070.4
98-02	All	All	All	**1W**	69	-136.34	1.6723	8.16	276.7	**1067.4**
98-02	All	All	All	**1E**	162	-353.86	1.8718	9.82	711.7	
98-02	All	All	All	**2**	20	-37.51	1.1769	24.66	79.0	
98-02	Abeam Closing	All	All	All	150	-313.63	1.7495	7.57	631.3	1073.1
98-02	Normal Closing	All	All	All	101	-218.94	1.8946	10.61	441.9	
98-02	All	Fore	All	All	207	-443.72	1.8859	6.61	891.4	1071.0
98-02	All	Center	All	All	44	-87.756	1.3093	18.84	179.5	
98-02	All	All	0-2	All	41	-86.818	1.5760	20.73	177.6	1073.7
98-02	All	All	3-5	All	210	-446.04	1.8319	6.50	896.1	
98-02	Abeam Closing	All	All	1W	39	-75.86	1.5594	12.04	155.7	1075.3
98-02	Normal Closing	All	All	1W	30	-60.26	1.7302	12.93	124.5	
98-02	Abeam Closing	All	All	1E	101	-217.28	1.9366	9.24	438.6	
98-02	Normal Closing	All	All	1E	61	-135.86	1.8367	24.71	275.7	
98-02	Abeam Closing	All	All	2	10	-16.03	0.5340	69.80	36.1	
98-02	Normal Closing	All	All	2	10	-20.35	1.4887	35.29	44.7	
98-02	All	Fore	All	1W	64	-127.45	1.6921	8.64	258.9	1073.1
98-02	All	Center	All	1W	5	-8.1429	1.4391	19.49	20.3	
98-02	All	Fore	All	1E	143	-313.17	2.0011	8.73	630.4	
98-02	All	Center	All	1E	19	-40.245	1.4102	38.85	84.5	
98-02	All	Center	All	2	20	-37.513	1.1769	24.66	79.0	
98-02	All	All	0-2	1W	18	-38.326	1.7817	23.94	80.7	1072.6
98-02	All	All	3-5	1W	51	-96.566	1.6587	7.71	197.1	
98-02	All	All	0-2	1E	19	-41.236	1.5464	42.28	86.5	
98-02	All	All	3-5	1E	143	-312.4	1.9573	9.05	628.8	
98-02	All	All	0-2	2	4	-4.5484	0.8922	31.48	13.1	
98-02	All	All	3-5	2	16	-31.237	1.0299	41.09	66.5	

Table 3b. For the past surveys (1988-1996), effective search half widths (*esw*) were calculated using a hazard-rate model without the adjustments. Sighting data was stratified by research mode, vessel's type (place of top barrel), Beaufort wind scale and sub-area. They were tested using Akaike's information criterion (AIC).

Data	Mode	Vessel	Wind	Sub-area	n	LnL	ESW	cv% (ESW)	AIC	Sum(AIC)
88-96	Normal Closing	All	All	All	355	-674.37	1.2039	6.00	1352.7	1352.7
88-96	Normal Closing	All	All	**1W**	**198**	**-379.20**	1.3613	6.67	762.4	**1352.1**
88-96	Normal Closing	All	All	**1E**	**121**	**-219.67**	0.8994	13.16	443.3	
88-96	Normal Closing	All	All	**2**	**36**	**-71.19**	0.8678	40.28	146.4	
88-96	Normal Closing	All	1-4	All	337	-644.12	1.2158	6.23	1292.2	1354.4
88-96	Normal Closing	All	5	All	18	-29.10	1.4089	9.74	62.2	
88-96	Normal Closing	Fore	All	All	186	-352.29	1.2405	7.75	708.6	1356.2
88-96	Normal Closing	Center	All	All	106	-209.25	1.4251	9.81	422.5	
88-96	Normal Closing	None	All	All	63	-110.57	0.8143	18.78	225.1	

Table 4a. For the recent surveys (1998-2002), The mean school size was estimated as constant and different over sub-area. The size bias was corrected by the regression of log (school size) on the detection probability with significance level at 0.15 (Buckland et al., 1993).

Data:	Mode	Sub-area	Intercept a	SE(a)	slope b	SE(b)	observations	df	Student-t	p-bvalue (T<t)	Mean school size	CV%	Expected school size	CV%
98-02	All	All	0.2451	0.0662	-0.0695	0.0789	251	249	-0.8809	0.1896	1.2988	2.83	1.2672	2.27
98-02	Abeam Closing	All	0.2513	0.0797	-0.0964	0.0942	150	148	-1.0233	0.1539	1.2667	3.40	1.2321	2.75
98-02	Normal Closing	All	0.2391	0.1189	-0.0323	0.1416	101	99	-0.2280	0.4101	1.3465	4.84	1.3241	3.96
98-02	All	1W	0.2940	0.1239	-0.2046	0.1380	69	67	-1.4828	0.0714	1.1884	5.00	1.1432 *	3.66
98-02	All	1E	0.2463	0.0869	-0.0509	0.1078	162	160	-0.4719	0.3188	1.3272	3.60	1.2988	2.95
98-02	All	2	0.1209	0.2004	0.2481	0.2543	20	18	0.9756	0.8289	1.4500	9.33	1.5672	9.31
98-02	Abeam Closing	1W	0.4864	0.1688	-0.3775	0.1925	39	37	-1.9614	0.0287	1.2821	7.55	1.1856 *	5.78
98-02	Normal Closing	1W	-0.0417	0.1179	0.1014	0.1309	30	28	0.7749	0.7775	1.0667	4.34	1.0791	3.33
98-02	Abeam Closing	1E	0.1984	0.1032	-0.0330	0.1209	101	99	-0.2730	0.3927	1.2574	3.98	1.2419	3.27
98-02	Normal Closing	1E	0.3707	0.1741	-0.1476	0.2358	61	59	-0.6261	0.2668	1.4426	6.59	1.3717	5.77
98-02	Abeam Closing	2	0.0709	0.1870	0.2518	0.2817	10	8	0.8940	0.8013	1.3000	11.75	1.4829	12.36
98-02	Normal Closing	2	0.1465	0.3691	0.3311	0.4706	10	8	0.7035	0.7491	1.6000	13.82	1.8064	15.92

Table 4b. For the recent surveys (1998-2002), The mean school sizes in each factor of mode, sub-area and mode × sub-area were assessed using multiple comparisons by the Bonferroni test. Combinations of sighting mode, sub-area and sighting mode×sub-area was tested with significance level at 0.05.

Multiple Comparison			**t**		**t(0.05)**
Abeam Closing	Nomal Closing		1.02	<	1.97
1W	**1E**		**2.99**	**>**	**2.41** *
1W	2		2.21	<	2.59
1E	2		0.86	<	2.58
Abeam Closing × 1W	Nomal Closing × 1W		1.28	<	3.05
Abeam Closing × 1W	Abeam Closing × 1E		1.04	<	3.03
Abeam Closing × 1W	Nomal Closing × 1E		2.34	<	3.01
Abeam Closing × 1W	Abeam Closing × 2		0.78	<	3.65
Abeam Closing × 1W	Nomal Closing × 2		1.86	<	3.83
Nomal Closing × 1W	Abeam Closing × 1E		2.80	<	3.01
Nomal Closing × 1W	**Nomal Closing × 1E**		**3.55**	**>**	**3.02** *
Nomal Closing × 1W	Abeam Closing × 2		1.46	<	3.83
Nomal Closing × 1W	Nomal Closing × 2		2.36	<	3.95
Abeam Closing × 1E	Nomal Closing × 1E		1.72	<	3.01
Abeam Closing × 1E	Abeam Closing × 2		0.27	<	3.73
Abeam Closing × 1E	Nomal Closing × 2		1.51	<	3.44
Nomal Closing × 1E	Abeam Closing × 2		0.79	<	3.65
Nomal Closing × 1E	Nomal Closing × 2		0.65	<	2.94
Abeam Closing × 2	Nomal Closing × 2		1.12	<	3.48

Table 5a. For the recent surveys, summary of abundance and estimation parameters of the base case (*esw*: stratified by sub-area, Mean school size: stratified by sub-area) for the abeam closing mode in each block.

Block	Lat	Long	Area	Sample No.	Observations n	Effort L n.m.	Effort Coverage %	ESW	CV % (ESW)	n/L	CV % n/L	Expected Cluster Size	CV % Exp Cluster Size	Density of clusters	CV % Density Clstrs	Density of whales	CV % (Density whls)	N	CV % N
1WW-M	25N-35N	130E-137.30E	188,870	1	0	111	33	-	-	-	-	-	-	-	-	-	-	-	-
1WW-L	10N-25N	130E-137.30E	385,344	5	2	756	61	1.6723	8.16	0.003	87.63	1.143	3.66	0.0008	88.01	0.0009	88.08	348	88.08
1WM-H	35N-43N	137.30'E-145E	81,960	1	0	230	82	-	-	-	-	-	-	-	-	-	-	-	-
1WM-M	25N-35N	137.30'E-145E	233,552	2	0	122	25	-	-	-	-	-	-	-	-	-	-	-	-
1WM-L	10N-25N	137.30'E-145E	384,389	4	2	1185	96	1.6723	8.16	0.002	105.36	1.143	3.66	0.0005	105.68	0.00058	105.74	222	105.74
1WE-H	31N-43N	145E-165E	692,020	4	22	1431	82	1.6723	8.16	0.015	72.51	1.143	3.66	0.0046	72.97	0.00525	73.06	3,635	73.06
1WE-M	20N-31N	145E-165E	663,632	6	12	1676	89	1.6723	8.16	0.007	52.13	1.143	3.66	0.0021	52.77	0.00245	52.90	1,624	52.90
1WE-L	10N-20N	145E-165E	692,984	2	1	1484	89	1.6723	8.16	0.001	111.12	1.143	3.66	0.0002	111.42	0.00023	111.48	160	111.48
1E-H	32N-39N	165E-180	309,600	5	34	1171	88	1.8718	9.82	0.029	55.65	1.327	3.60	0.0078	56.51	0.0103	56.63	3,186	56.63
1E-M	20N-32N	165E-180	581,514	2	66	1531	96	1.8718	9.82	0.043	72.81	1.327	3.60	0.0115	73.47	0.01529	73.56	8,889	73.56
1E-L	10N-20N	165E-180	519,738	1	1	637	86	1.8718	9.82	0.002	110.20	1.327	3.60	0.0004	110.64	0.00056	110.70	289	110.70
2-H	35N-39N	180-155W	289,250	3	6	646	89	1.1769	24.66	0.009	49.96	1.450	9.33	0.0039	55.71	0.0057	56.49	1,656	56.49
2-M	25N-35N	180-155W	778,545	5	4	1095	62	1.1769	24.66	0.004	79.71	1.450	9.33	0.0016	83.44	0.00225	83.96	1,752	83.96

Table 5b. For the recent surveys, summary of abundance and estimation parameters of the base case (*esw*: stratified by sub-area, Mean school size: stratified by sub-area) for the normal closing mode in each block.

Block	Lat	Long	Area	Sample No.	Observations n	Effort L n.m.	Effort Coverage %	ESW	CV % (ESW)	n/L	CV % (n/L)	Expected Cluster Size	CV % Exp Cluster S	Density of clusters	CV % (Density Clstrs	Density of whales	CV % (Density whls)	N	CV% (N)
1WW-M	25N-35N	130E-137.30E	188,870	1	0	153	38	-	-	-	-	-	-	-	-	-	-	-	-
1WW-L	10N-25N	130E-137.30E	385,344	5	0	1125	91	-	-	-	-	-	-	-	-	-	-	-	-
1WM-H	35N-43N	137.30'E-145E	81,960	1	0	81	30	-	-	-	-	-	-	-	-	-	-	-	-
1WM-M	25N-35N	137.30'E-145E	233,552	2	0	94	20	-	-	-	-	-	-	-	-	-	-	-	-
1WM-L	10N-25N	137.30'E-145E	384,389	4	4	1109	92	1.6723	8.16	0.004	70.22	1.143	3.66	0.0011	70.69	0.00123	70.79	474	70.79
1WE-H	31N-43N	145E-165E	692,020	5	3	1006	61	1.6723	8.16	0.003	41.05	1.143	3.66	0.0009	41.86	0.00102	42.02	705	42.02
1WE-M	20N-31N	145E-165E	663,632	6	21	1574	60	1.6723	8.16	0.013	47.88	1.143	3.66	0.0040	48.57	0.00456	48.71	3,026	48.71
1WE-L	10N-20N	145E-165E	692,984	3	2	1056	63	1.6723	8.16	0.002	56.73	1.143	3.66	0.0006	57.31	0.00065	57.43	449	57.43
1E-H	32N-39N	165E-180	309,600	5	29	1018	76	1.8718	9.82	0.028	33.40	1.327	3.60	0.0076	34.81	0.0101	35.00	3,128	35.00
1E-M	20N-32N	165E-180	581,514	4	31	1145	77	1.8718	9.82	0.027	48.46	1.327	3.60	0.0072	49.44	0.0096	49.58	5,580	49.58
1E-L	10N-20N	165E-180	519,738	1	1	729	98	1.8718	9.82	0.001	62.80	1.327	3.60	0.0004	63.56	0.00049	63.66	253	63.66
2-H	35N-39N	180-155W	289,250	3	5	557	69	1.1769	24.66	0.009	69.48	1.450	9.33	0.0038	73.73	0.0055	74.31	1,598	74.31
2-M	25N-35N	180-155W	778,545	5	5	986	66	1.1769	24.66	0.005	48.55	1.450	9.33	0.0022	54.45	0.00313	55.25	2,433	55.25

Table 5c. For the recent surveys, summary of abundance and estimation parameters of the reference case (*esw*: constant in all area, Mean school size: constant in all area) for the abeam closing mode in each block.

Block	Lat	Long	Area	Sample No.	Observations n	Effort L nm	Effort Coverage %	ESW	CV % (ESW)	n/L	CV % n/L	Expected Cluster Size	CV % Exp Cluster Size	Density of clusters	CV % Density Clstrs	Density of whales	CV % (Density whls)	N	CV % (N)
1WW-M	25N-35N	130E-137.30E	188,870	1	0	111	33	-	-	-	-	-	-	0	-	0	-	0	-
1WW-L	10N-25N	130E-137.30E	385,344	5	2	756	61	1.7936	6.31	0.003	87.63	1.299	2.83	0.0007	87.85	0.00096	87.90	369	87.90
1WM-H	35N-43N	137.30'E-145E	81,960	1	0	230	82	-	-	-	-	-	-	0	-	0	-	0	-
1WM-M	25N-35N	137.30'E-145E	233,552	2	0	122	25	-	-	-	-	-	-	0	-	0	-	0	-
1WM-L	10N-25N	137.30'E-145E	384,389	4	2	1185	96	1.7936	6.31	0.002	105.36	1.299	2.83	0.0005	105.55	0.0006	105.59	235	105.59
1WE-H	31N-43N	145E-165E	692,020	4	22	1431	82	1.7936	6.31	0.015	72.51	1.299	2.83	0.0043	72.78	0.00556	72.84	3,851	72.84
1WE-M	20N-31N	145E-165E	663,632	6	12	1676	89	1.7936	6.31	0.007	52.13	1.299	2.83	0.0020	52.52	0.00259	52.59	1,721	52.59
1WE-L	10N-20N	145E-165E	692,984	2	1	1484	89	1.7936	6.31	0.001	111.12	1.299	2.83	0.0002	111.30	0.00024	111.33	169	111.33
1E-H	32N-39N	165E-180	309,600	5	34	1171	88	1.7936	6.31	0.029	55.65	1.299	2.83	0.0081	56.01	0.0105	56.08	3,254	56.08
1E-M	20N-32N	165E-180	581,514	2	66	1531	96	1.7936	6.31	0.043	72.81	1.299	2.83	0.0120	73.08	0.01561	73.14	9,078	73.14
1E-L	10N-20N	165E-180	519,738	1	1	637	86	1.7936	6.31	0.002	110.20	1.299	2.83	0.0004	110.76	0.00057	110.80	295	110.80
2-H	35N-39N	180-155W	289,250	3	6	646	89	1.7936	6.31	0.009	49.96	1.299	2.83	0.0020	56.67	0.0026	56.74	973	50.44
2-M	25N-35N	180-155W	778,545	5	4	1095	62	1.7936	6.31	0.004	79.71	1.299	2.83	0.0010	79.96	0.00132	80.01	1,030	80.01

Table 5d. For the recent surveys, summary of abundance and estimation parameters of the reference case (*esw*: constant in all area, Mean school size: constant in all area) for the normal closing mode in each block.

Block	Lat	Long	Area	Sample		Effort		ESW	CV %	n/L	CV %	Expected	CV %	Density	CV %	Density	CV %	N	CV%
				No.	n	L nm	Coverage %		(ESW)		(n/L)	Cluster Size	(Exp Cluster Size)	of clusters	(Density Clstrs)	of whales	(Density whls)		(N)
1WW-M	25N-35N	130E-137.30E	188,870	1	0	153	38	-	-	-	-	-	-	0	-	0	-	0	-
1WW-L	10N-25N	130E-137.30E	385,344	5	0	1125	91	-	-	-	-	-	-	0	-	0	-	0	-
1WM-H	35N-43N	137.30'E-145E	81,960	1	0	81	30	-	-	-	-	-	-	0	-	0	-	0	-
1WM-M	25N-35N	137.30'E-145E	233,552	2	0	94	20	-	-	-	-	-	-	0	-	0	-	0	-
1WM-L	10N-25N	137.30'E-145E	384,389	4	4	1109	92	1.7936	6.31	0.004	70.22	1.299	2.83	0.0010	70.51	0.00131	70.56	502	70.56
1WE-H	31N-43N	145E-165E	692,020	5	3	1006	61	1.7936	6.31	0.003	41.05	1.299	2.83	0.0008	41.54	0.00108	41.63	747	41.63
1WE-M	20N-31N	145E-165E	663,632	6	21	1574	60	1.7936	6.31	0.013	47.88	1.299	2.83	0.0037	48.30	0.00483	48.38	3,205	48.38
1WE-L	10N-20N	145E-165E	692,984	3	2	1056	63	1.7936	6.31	0.002	56.73	1.299	2.83	0.0005	57.08	0.00069	57.15	475	57.15
1E-H	32N-39N	165E-180	309,600	5	29	1018	76	1.7936	6.31	0.028	33.40	1.299	2.83	0.0020	56.67	0.0026	56.74	3,194	34.11
1E-M	20N-32N	165E-180	581,514	4	31	1145	77	1.7936	6.31	0.027	48.46	1.299	2.83	0.0075	48.87	0.0098	48.95	5,699	48.95
1E-L	10N-20N	165E-180	519,738	1	1	729	98	1.7936	6.31	0.001	62.80	1.299	2.83	0.0004	63.11	0.0005	63.18	258	63.18
2-H	35N-39N	180-155W	289,250	3	5	557	69	1.7936	6.31	0.009	69.48	1.299	2.83	0.0021	67.80	0.0027	67.86	939	69.82
2-M	25N-35N	180-155W	778,545	5	5	986	66	1.7936	6.31	0.005	48.55	1.299	2.83	0.0014	48.96	0.00184	49.04	1,430	49.04

Table 6. Sample size, leg-based and 1 degree-based CV of n/L in each block during normal closing mode in the recent surveys in order to calibrate a difference between sampling units .

Block	1WM-L	1WE-H	1WE-M	1WE-L	1E-H	1E-M	1E-L	2-H	2-M
n	4	3	21	2	29	31	1	5	5
$CV^{leg}(n/L)$	70.22	41.05	47.88	56.73	33.40	48.46	62.80	69.48	48.55
$CV^{1deg}(n/L$	56.22	48.10	24.79	58.48	37.57	30.49	102.91	63.18	48.64

Table 7a. For the past surveys (1988-1996), summary of abundance and estimation parameters of the base case (*esw*: stratified by sub-area, Mean school size: stratified by sub-area) for the normal closing mode in each block.

Year	Block	Lat	Long	Area	Sample No.	Observations	L	ESW	CV % (ESW)	n/L	CV % (n/L)	Calibration factor of sampling unit	CV % (n/L)	Expected Cluster Size	CV % (Exp Cluster	Density of clusters	CV % (Density Clstrs)	Density of whales	CV % (Density whls)	N	CV% (N)
93	1WW-M	25-34	130-137.30	188,870	30	2	1596.7	1.3613	6.67	0.001	74.20	0.90	66.44	1.269	2.52	0.000	66.78	0.001	66.82	110	66.82
93	1WW-L	10-24	130-137.30	385,344	21	10	842.7	1.3613	6.67	0.012	47.08	1.23	57.68	1.269	2.52	0.004	58.06	0.006	58.12	2,132	58.12
94		10-24	130-137.30	385,344	6	1	205.5	1.3613	6.67	0.005	88.10	0.78	68.93	1.269	2.52	0.002	69.25	0.002	69.30	874	69.30
96		10-24	130-137.30	385,344	16	4	670.5	1.3613	6.67	0.006	97.74	1.02	100.17	1.269	2.52	0.002	100.40	0.003	100.43	1,072	100.43
89	1WM-H	35-42	137.30-144	81,960	13	1	432.2	1.3613	6.67	0.002	51.97	0.78	40.66	1.269	2.52	0.001	41.20	0.001	41.28	88	41.28
93	1WM-L	10-24	137.30-144	384,389	25	5	1131.3	1.3613	6.67	0.004	52.14	1.07	55.81	1.269	2.52	0.002	56.21	0.002	56.27	792	56.27
96		10-24	137.30-144	384,389	10	4	393.9	1.3613	6.67	0.010	68.41	1.02	70.11	1.269	2.52	0.004	70.43	0.005	70.47	1,820	70.47
88	1WE-H	31-42	145-164	692,020	118	21	4948.2	1.3613	6.67	0.004	37.07	1.42	52.48	1.269	2.52	0.002	52.90	0.002	52.96	1,369	52.96
89		31-42	145-164	692,020	111	25	4180.8	1.3613	6.67	0.006	32.31	1.46	47.32	1.269	2.52	0.002	47.79	0.003	47.85	1,929	47.85
90		31-42	145-164	692,020	95	13	3812.5	1.3613	6.67	0.003	58.97	1.29	76.03	1.269	2.52	0.001	76.33	0.002	76.37	1,100	76.37
92		31-42	145-164	692,020	113	37	5600.9	1.3613	6.67	0.007	28.09	1.58	44.40	1.269	2.52	0.002	44.90	0.003	44.97	2,131	44.97
93		31-42	145-164	692,020	43	14	1279.4	1.3613	6.67	0.011	97.74	1.31	127.86	1.269	2.52	0.004	128.03	0.005	128.05	3,531	128.05
88	1WE-M	20-30	145-164	663,632	7	1	292.3	1.3613	6.67	0.003	106.74	0.78	83.51	1.269	2.52	0.001	83.78	0.002	83.81	1,059	83.81
89		20-30	145-164	663,632	53	7	2139.2	1.3613	6.67	0.004	43.89	1.14	50.16	1.269	2.52	0.001	50.60	0.002	50.67	1,012	50.67
90		20-30	145-164	663,632	21	2	768.0	1.3613	6.67	0.003	61.72	0.90	55.27	1.269	2.52	0.001	55.67	0.001	55.73	806	55.73
91		20-30	145-164	663,632	18	1	518.4	1.3613	6.67	0.002	83.20	0.78	65.09	1.269	2.52	0.001	65.43	0.001	65.48	597	65.48
92		20-30	145-164	663,632	23	3	1122.6	1.3613	6.67	0.003	51.69	0.97	50.09	1.269	2.52	0.001	50.53	0.001	50.60	827	50.60
93		20-30	145-164	663,632	36	11	986.6	1.3613	6.67	0.011	42.47	1.25	53.01	1.269	2.52	0.004	53.42	0.005	53.48	3,450	53.48
93	1WE-L	10-19	145-164	692,984	43	17	1829.6	1.3613	6.67	0.009	52.10	1.36	70.78	1.269	2.52	0.003	71.09	0.004	71.14	3,002	71.14
94		10-19	145-164	692,984	14	5	736.3	1.3613	6.67	0.007	74.76	1.07	80.02	1.269	2.52	0.002	80.30	0.003	80.34	2,194	80.34
96		10-19	145-164	692,984	34	14	1303.6	1.3613	6.67	0.011	34.01	1.31	44.49	1.269	2.52	0.004	44.99	0.005	45.06	3,470	45.06
88	1E-H	32-39	165-179	309,600	41	6	1616.4	0.8994	13.16	0.003	50.60	1.11	56.12	1.574	4.60	0.002	57.64	0.003	57.83	1,006	57.83
89		32-39	165-179	309,600	45	33	2061.7	0.8994	13.16	0.012	36.33	1.55	56.16	1.574	4.60	0.009	57.68	0.014	57.87	4,337	57.87
90		32-39	165-179	309,600	38	9	1615.1	0.8994	13.16	0.004	36.98	1.20	44.39	1.574	4.60	0.003	46.30	0.005	46.52	1,510	46.52
91		32-39	165-179	309,600	7	2	130.7	0.8994	13.16	0.019	32.88	0.90	29.44	1.574	4.60	0.009	32.25	0.013	32.58	4,146	32.58
93		32-39	165-179	309,600	21	38	755.2	0.8994	13.16	0.036	45.91	1.59	72.95	1.574	4.60	0.028	74.13	0.044	74.27	13,634	74.27
89	1E-M	20-31	165-179	581,514	24	3	1049.9	0.8994	13.16	0.003	66.41	0.97	64.35	1.574	4.60	0.002	65.69	0.003	65.85	1,454	65.85
90		20-31	165-179	581,514	49	9	1604.7	0.8994	13.16	0.006	42.20	1.20	50.65	1.574	4.60	0.003	52.33	0.005	52.53	2,854	52.53
91		20-31	165-179	581,514	21	6	663.9	0.8994	13.16	0.009	28.56	1.11	31.68	1.574	4.60	0.005	34.30	0.008	34.61	4,599	34.61
93		20-31	165-179	581,514	27	12	856.3	0.8994	13.16	0.014	102.51	1.27	130.13	1.574	4.60	0.008	130.79	0.012	130.87	7,132	130.87
93	1E-L	10-19	165-179	519,738	31	3	2193.5	0.8994	13.16	0.001	75.29	0.97	72.96	1.574	4.60	0.001	74.14	0.001	74.28	622	74.28
88	2-H	35-39	180-204	289,250	38	10	1456.6	0.8678	40.28	0.003	35.29	1.23	43.24	1.389	7.19	0.004	59.09	0.005	59.53	1,589	59.53
89		35-39	180-204	289,250	28	2	1513.0	0.8678	40.28	0.001	74.53	0.90	66.74	1.389	7.19	0.001	77.95	0.001	78.28	306	78.28
90		35-39	180-204	289,250	18	1	582.0	0.8678	40.28	0.001	75.73	0.78	59.25	1.389	7.19	0.001	71.64	0.001	72.00	398	72.00
91		35-39	180-204	289,250	6	2	282.2	0.8678	40.28	0.003	82.53	0.90	73.90	1.389	7.19	0.004	84.17	0.006	84.47	1,641	84.47
88	2-M	25-34	180-204	778,545	42	8	1605.0	0.8678	40.28	0.005	52.03	1.17	61.03	1.389	7.19	0.003	73.13	0.004	73.48	3,105	73.48
89		25-34	180-204	778,545	53	5	1998.6	0.8678	40.28	0.003	75.20	1.07	80.50	1.389	7.19	0.001	90.01	0.002	90.30	1,559	90.30
90		25-34	180-204	778,545	46	2	1646.2	0.8678	40.28	0.001	126.42	0.90	113.20	1.389	7.19	0.001	120.16	0.001	120.37	757	120.37
91		25-34	180-204	778,545	23	6	623.0	0.8678	40.28	0.010	64.44	1.11	71.47	1.389	7.19	0.006	82.04	0.008	82.35	6,000	82.35

Table 7b. For the past surveys (1988-1996), summary of abundance and estimation parameters of the reference case (esw: constant in all area, Mean school size: constant in all area) for the normal closing mode in each block.

Year	Block	Lat	Long	Area	Sample No.	Observations	L	ESW	CV % (ESW)	n/L	CV % (n/L)	Calibration factor of sampling unit	CV % (n/L)	Expected Cluster Size	CV % (Exp Cluster	Density of clusters	CV % (Density Clstrs)	Density of whales	CV % (Density whls)	N	CV% (N)
93	1WW-M	25-34	130-137.30	188,870	30	2	1596.7	1.2039	6.00	0.001	74.20	0.90	66.44	1.415	2.28	0.001	66.71	0.001	66.75	139	66.75
93	1WW-L	10-24	130-137.30	385,344	21	10	842.7	1.2039	6.00	0.012	47.08	1.23	57.68	1.415	2.28	0.005	57.99	0.007	58.04	2,688	58.04
94		10-24	130-137.30	385,344	6	1	205.5	1.2039	6.00	0.005	88.10	0.78	68.93	1.415	2.28	0.002	69.19	0.003	69.23	1,102	69.23
96		10-24	130-137.30	385,344	16	4	670.5	1.2039	6.00	0.006	97.74	1.02	100.17	1.415	2.28	0.002	100.35	0.004	100.38	1,351	100.38
89	1WM-H	35-42	137.30-144	81,960	13	1	432.2	1.2039	6.00	0.002	51.97	0.78	40.66	1.415	2.28	0.001	41.10	0.001	41.16	111	41.16
93	1WM-L	10-24	137.30-144	384,389	25	5	1131.3	1.2039	6.00	0.004	52.14	1.07	55.81	1.415	2.28	0.002	56.13	0.003	56.18	999	56.18
96		10-24	137.30-144	384,389	10	4	393.9	1.2039	6.00	0.010	68.41	1.02	70.11	1.415	2.28	0.004	70.37	0.006	70.41	2,295	70.41
88	1WE-H	31-42	145-164	692,020	118	21	4948.2	1.2039	6.00	0.004	37.07	1.42	52.48	1.415	2.28	0.002	52.82	0.002	52.87	1,726	52.87
89		31-42	145-164	692,020	111	25	4180.8	1.2039	6.00	0.006	32.31	1.46	47.32	1.415	2.28	0.002	47.70	0.004	47.75	2,433	47.75
90		31-42	145-164	692,020	95	13	3812.5	1.2039	6.00	0.003	58.97	1.29	76.03	1.415	2.28	0.001	76.27	0.002	76.30	1,387	76.30
92		31-42	145-164	692,020	113	37	5600.9	1.2039	6.00	0.007	28.09	1.58	44.40	1.415	2.28	0.003	44.81	0.004	44.86	2,687	44.86
93		31-42	145-164	692,020	43	14	1279.4	1.2039	6.00	0.011	97.74	1.31	127.86	1.415	2.28	0.005	128.00	0.006	128.02	4,451	128.02
88	1WE-M	20-30	145-164	663,632	7	1	292.3	1.2039	6.00	0.003	106.74	0.78	83.51	1.415	2.28	0.001	83.73	0.002	83.76	1,335	83.76
89		20-30	145-164	663,632	53	7	2139.2	1.2039	6.00	0.004	43.89	1.14	50.16	1.415	2.28	0.001	50.52	0.002	50.57	1,277	50.57
90		20-30	145-164	663,632	21	2	768.0	1.2039	6.00	0.003	61.72	0.90	55.27	1.415	2.28	0.001	55.59	0.002	55.64	1,016	55.64
91		20-30	145-164	663,632	18	1	518.4	1.2039	6.00	0.002	83.20	0.78	65.09	1.415	2.28	0.001	65.37	0.001	65.41	753	65.41
92		20-30	145-164	663,632	23	3	1122.6	1.2039	6.00	0.003	51.69	0.97	50.09	1.415	2.28	0.001	50.45	0.002	50.50	1,043	50.50
93		20-30	145-164	663,632	36	11	986.6	1.2039	6.00	0.011	42.47	1.25	53.01	1.415	2.28	0.005	53.35	0.007	53.39	4,350	53.39
93	1WE-L	10-19	145-164	692,984	43	17	1829.6	1.2039	6.00	0.009	52.10	1.36	70.78	1.415	2.28	0.004	71.03	0.005	71.07	3,785	71.07
94		10-19	145-164	692,984	14	5	736.3	1.2039	6.00	0.007	74.76	1.07	80.02	1.415	2.28	0.003	80.25	0.004	80.28	2,766	80.28
96		10-19	145-164	692,984	34	14	1303.6	1.2039	6.00	0.011	34.01	1.31	44.49	1.415	2.28	0.004	44.89	0.006	44.95	4,375	44.95
88	1E-H	32-39	165-179	309,600	41	6	1616.4	1.2039	6.00	0.003	50.60	1.11	56.12	1.415	2.28	0.002	56.44	0.002	56.49	676	56.49
89		32-39	165-179	309,600	45	33	2061.7	1.2039	6.00	0.012	36.33	1.55	56.16	1.415	2.28	0.007	56.48	0.009	56.53	2,913	56.53
90		32-39	165-179	309,600	38	9	1615.1	1.2039	6.00	0.004	36.98	1.20	44.39	1.415	2.28	0.002	44.79	0.003	44.85	1,014	44.85
91		32-39	165-179	309,600	7	2	130.7	1.2039	6.00	0.019	32.88	0.90	29.44	1.415	2.28	0.006	30.05	0.009	30.13	2,785	30.13
93		32-39	165-179	309,600	21	38	755.2	1.2039	6.00	0.036	45.91	1.59	72.95	1.415	2.28	0.021	73.20	0.030	73.23	9,158	73.23
89	1E-M	20-31	165-179	581,514	24	3	1049.9	1.2039	6.00	0.003	66.41	0.97	64.35	1.415	2.28	0.001	64.63	0.002	64.67	977	64.67
90		20-31	165-179	581,514	49	9	1604.7	1.2039	6.00	0.006	42.20	1.20	50.65	1.415	2.28	0.002	51.00	0.003	51.06	1,917	51.06
91		20-31	165-179	581,514	21	6	663.9	1.2039	6.00	0.009	28.56	1.11	31.68	1.415	2.28	0.004	32.24	0.005	32.32	3,089	32.32
93		20-31	165-179	581,514	27	12	856.3	1.2039	6.00	0.014	102.51	1.27	130.13	1.415	2.28	0.006	130.27	0.008	130.29	4,791	130.29
93	1E-L	10-19	165-179	519,738	31	3	2193.5	1.2039	6.00	0.001	75.29	0.97	72.96	1.415	2.28	0.001	73.21	0.001	73.24	418	73.24
88	2-H	35-39	180-204	289,250	38	10	1456.6	1.2039	6.00	0.003	35.29	1.23	43.24	1.415	2.28	0.003	43.65	0.004	43.71	1,167	43.71
89		35-39	180-204	289,250	28	2	1513.0	1.2039	6.00	0.001	74.53	0.90	66.74	1.415	2.28	0.001	67.01	0.001	67.05	225	67.05
90		35-39	180-204	289,250	18	1	582.0	1.2039	6.00	0.001	75.73	0.78	59.25	1.415	2.28	0.001	59.55	0.001	59.60	292	59.60
91		35-39	180-204	289,250	6	2	282.2	1.2039	6.00	0.003	82.53	0.90	73.90	1.415	2.28	0.003	74.15	0.004	74.18	1,205	74.18
88	2-M	25-34	180-204	778,545	42	8	1605.0	1.2039	6.00	0.005	52.03	1.17	61.03	1.415	2.28	0.002	61.33	0.003	61.37	2,281	61.37
89		25-34	180-204	778,545	53	5	1998.6	1.2039	6.00	0.003	75.20	1.07	80.50	1.415	2.28	0.001	80.72	0.001	80.75	1,145	80.75
90		25-34	180-204	778,545	46	2	1646.2	1.2039	6.00	0.001	126.42	0.90	113.20	1.415	2.28	0.001	113.36	0.001	113.39	556	113.39
91		25-34	180-204	778,545	23	6	623.0	1.2039	6.00	0.010	64.44	1.11	71.47	1.415	2.28	0.004	71.72	0.006	71.76	4,408	71.76

Table 8a. For the past and recent surveys (1988-2002), summary of abundance estimates and their CV%s of the base case (*esw*: stratified by sub-area, Mean school size: stratified by sub-area) in each block. Upper and below value in the block shows abundance and CV%, respectively.

Year/Block	1WW-M	1WW-L	1WM-H	1WM-M	1WM-L	1WE-H	1WE-M	1WE-L	1E-H	1E-M	1E-L	2-H	2-M
Latitude	25°N-35°	10°N-25°N	35°N-43°N	25°N-35°N	10°N-25°N	31°N-43°N	20°N-31°N	10°N-20°N	32°N-39°N	20°N-32°N	10°N-20°N	35°N-39°N	25°N-35°N
Longitude	130°E-137°30'E	130°E-137°30'E	137°30'E-145°E	137°30'E-145°E	137°30'E-145°E	145°E-165°E	145°E-165°E	145°E-165°E	165°E-180°	165°E-180°	165°E-180°	180°-155W	180°-155W
Area (nm^2)	188,870	385,344	81,960	233,552	384,389	692,020	663,632	692,984	309,600	581,514	519,738	289,250	778,545
Past surveys (Normal closing mode)													
1988				**0**		**1,369** 52.96	**1,059** 83.81		**1,006** 57.83			**1,589** 59.53	**3,105** 73.48
1989			**88** 41.28	**0**		**1,929** 47.85	**1,012** 50.67		**4,337** 57.87	**1,454** 65.84		**306** 78.28	**1,559** 90.30
1990			**0**	**0**		**1,100** 76.37	**806** 55.73		**1,510** 46.52	**2,854** 52.53		**398** 72.00	**757** 120.37
1991	**0**		**0**			**0** 0.00	**597** 65.48		**4,146** 32.58	**4,599** 34.61		**1,641** 84.47	**6,000** 82.35
1992	**0**		**0**	**0**		**2,131** 44.97	**827** 50.60						
1993	**110** 66.82	**2,132** 58.12		**0**	**792** 56.27	**3,531** 128.05	**3,450** 53.48	**3,002** 71.14	**13,634** 74.27	**7,132** 130.87	**622** 74.28		
1994		**874** 69.30						**2,194** 80.34					
1995	**0**		**0**	**0**			**0**			**0**	**0**		
1996		**1,072** 100.43	**0**		**1,820** 70.47		**0**	**3,470** 45.06					
Recent surveys (Abeam closing mode)													
1998						**3,635** 73.06	**1,624** 52.90	**160** 111.48					
1999									**3,186** 56.63	**8,889** 73.56	**289** 110.70		
2000			**0**	**0**	**222** 105.74								
2001	**0**	**348** 88.08											
2002												**1,656** 56.49	**1,752** 83.96
Recent surveys (Normal closing mode)													
1998						**705** 42.02	**3,026** 48.71	**449** 57.43					
1999									**3,128** 35.00	**5,580** 49.58	**253** 63.66		
2000			**0**	**0**	**474** 70.79								
2001	**0**	**0**											
2002												**1,598** 74.31	**2,433** 55.25

Table 8b. For the past and recent surveys (1988-2002), summary of abundance estimates and their CV%s of t reference case (*esw*: constant in all area, Mean school size: constant in all area) in each block. Upper and below value in the block shows abundance and CV%, respectively.

Year/Block	1WW-M	1WW-L	1WM-H	1WM-M	1WM-L	1WE-H	1WE-M	1WE-L	1E-H	1E-M	1E-L	2-H	2-M
Latitude	25°N-35°	10°N-25°N	35°N-43°N	25°N-35°N	10°N-25°N	31°N-43°N	20°N-31°N	10°N-20°N	32°N-39°N	20°N-32°N	10°N-20°N	35°N-39°N	25°N-35°N
Longitude	130°B-137°30'E	130°B-137°30'E	137°30'E-145°E	137°30'E-145°E	137°30'E-145°E	145°E-165°E	145°E-165°E	145°E-165°E	165°E-180°	165°E-180°	165°E-180°	180°-155W	180°-155W
Area (nm^2)	188,870	385,344	81,960	233,552	384,389	692,020	663,632	692,984	309,600	581,514	519,738	289,250	778,545
Past surveys (Normal closing mode)													
1988				**0**		**1,726** 52.87	**1,335** 83.76		**676** 56.49			**1,167** 43.71	**2,281** 61.37
1989			**111** 41.16	**0**		**2,433** 47.75	**1,277** 50.57		**2,913** 56.53	**977** 64.67		**225** 67.05	**1,145** 80.75
1990			**0**	**0**		**1,387** 76.30	**1,016** 55.64		**1,014** 44.85	**1,917** 51.06		**292** 59.60	**556** 113.39
1991	**0**		**0**			**0** 0.00	**753** 65.41		**2,785** 30.13	**3,089** 32.32		**1,205** 74.18	**4,408** 71.76
1992	**0**		**0**	**0**		**2,687** 44.86	**1,043** 50.50						
1993	**139** 66.75	**2,688** 58.04		**0**	**999** 56.18	**4,451** 128.02	**4,350** 53.39	**3,785** 71.07	**9,158** 73.23	**4,791** 130.29	**418** 73.24		
1994		**1,102** 69.23						**2,766** 80.28					
1995	**0**		**0**	**0**			**0**			**0**	**0**		
1996		**1,351** 100.38	**0**		**2,295** 70.41		**0**	**4,375** 44.95					
Recent surveys (Abeam closing mode)													
1998						**3,851** 72.84	**1,721** 52.59	**169** 111.33					
1999									**3,254** 56.08	**9,078** 73.14	**295** 110.80		
2000			**0**	**0**	**235** 105.59								
2001	**0**	**369** 87.90											
2002												**973** 50.44	**1,030** 80.01
Recent surveys (Normal closing mode)													
1998						**747** 41.63	**3,205** 48.38	**475** 57.15					
1999									**3,194** 34.11	**5,699** 48.95	**258** 63.18		
2000			**0**	**0**	**502** 70.56								
2001	**0**	**0**											
2002												**939** 69.82	**1,430** 49.04

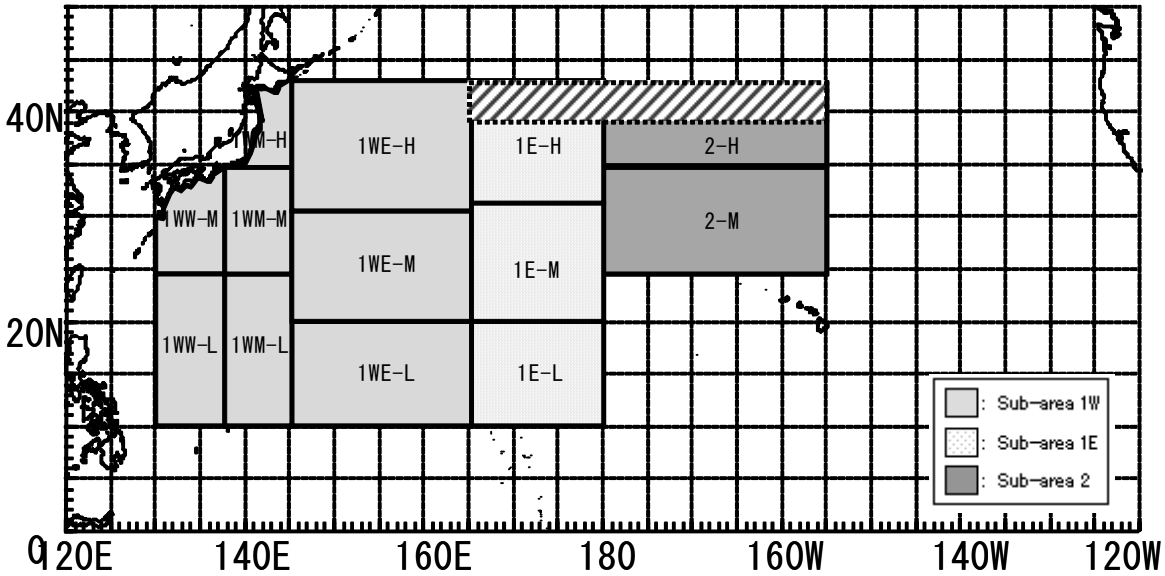


Fig. 1, Names and positions of blocks as strata estimated abundance of the western North Pacific Bryde's whales in August and September from 1998 to 2002. Sub-area 1W, 1E and 2 is shown as three gradations of gray. The recent sighting survey conducted in the sub-area 1W bounded from 130˚ E to 165˚E and from 10˚N to 43˚ N, in the sub-area 1E bounded from 165˚ E to 180˚ and from 10˚N to 43˚ N and in the sub-area 2 bounded from 180˚ to 155˚ W and from 25˚N to 43˚ N. The northern part (north of 39˚ N) of 1E-H and 2-H block excluded this abundance estimation because of low effort, shown as mesh and dotted line. .

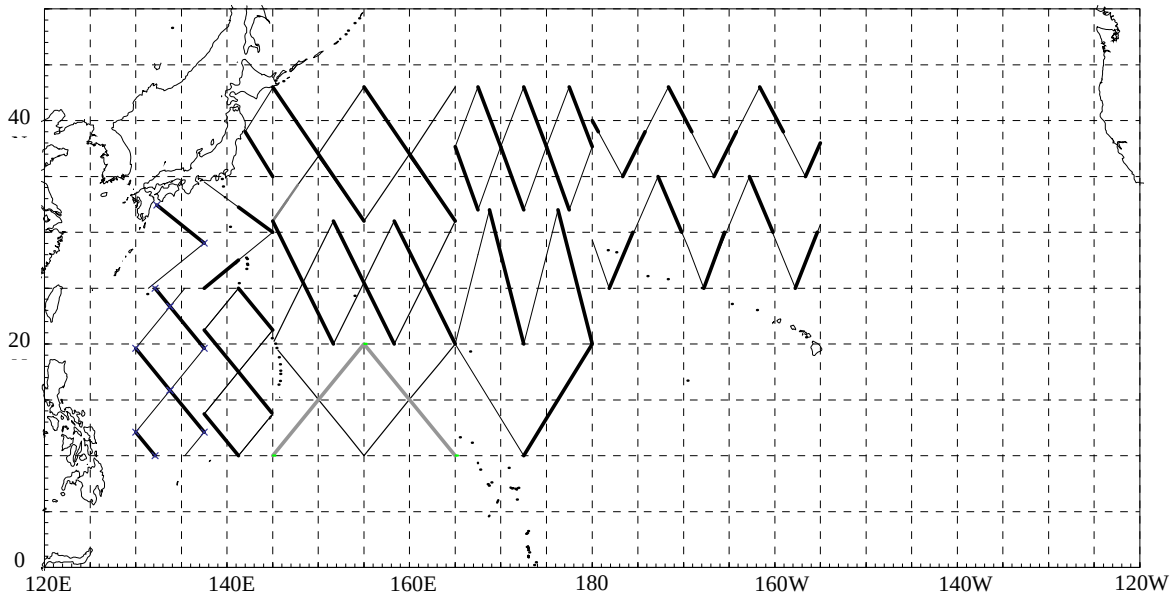


Fig. 2. Pre-determined cruise track lines by normal closing and abeam closing mode during the western North Pacific Bryde's whale sightings survey in August and September,1998-2002. Thin, thick and gray lines shows normal closing, abeam closing mode and SCANS mode survey respectively.

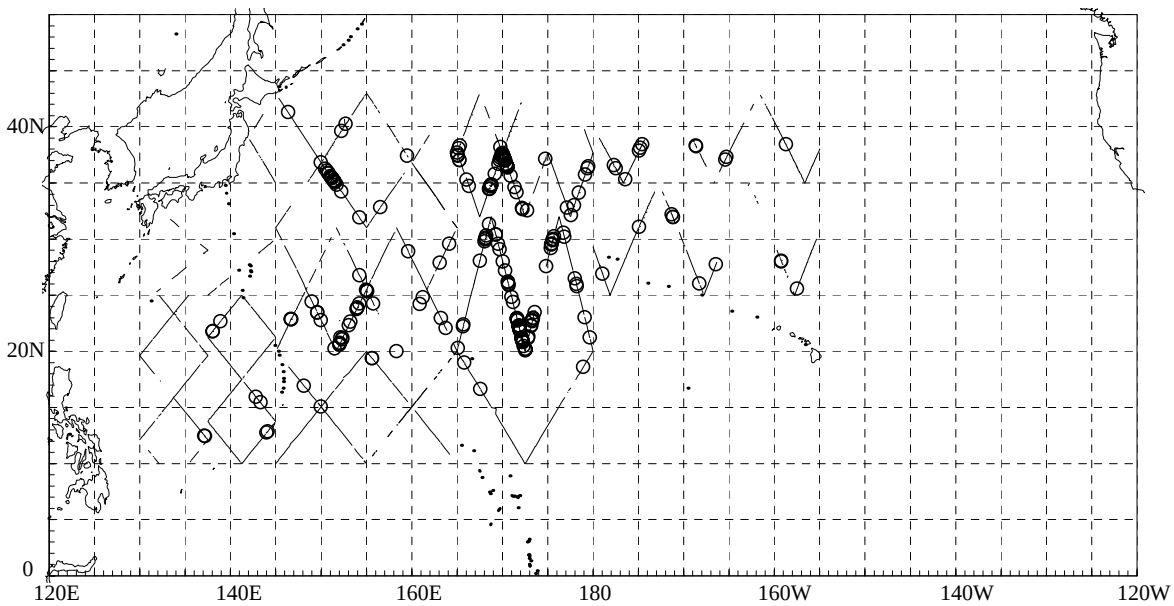


Fig. 3. Primary sighting positions of Bryde’s whale and the predetermined cruise track lines on effort in the Bryde's whale sighting survey in August and September, 1998-2002

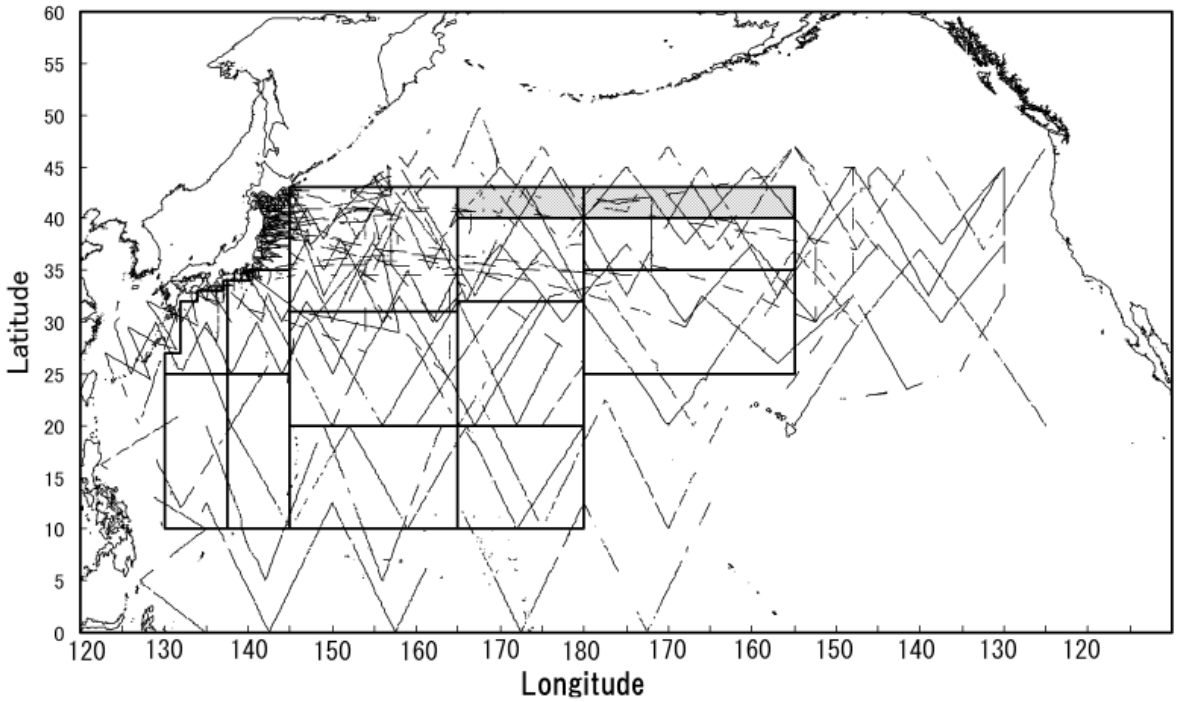


Fig. 4, Pre-determined cruise track lines on effort during the past sightings surveys in August and September,1988-1996. The northern part (north of 39° N) of 1E-H and 2-H block excluded this abundance estimation to keep consistency of estimation in the recent surveys that were not covered enough, shown as gray color.

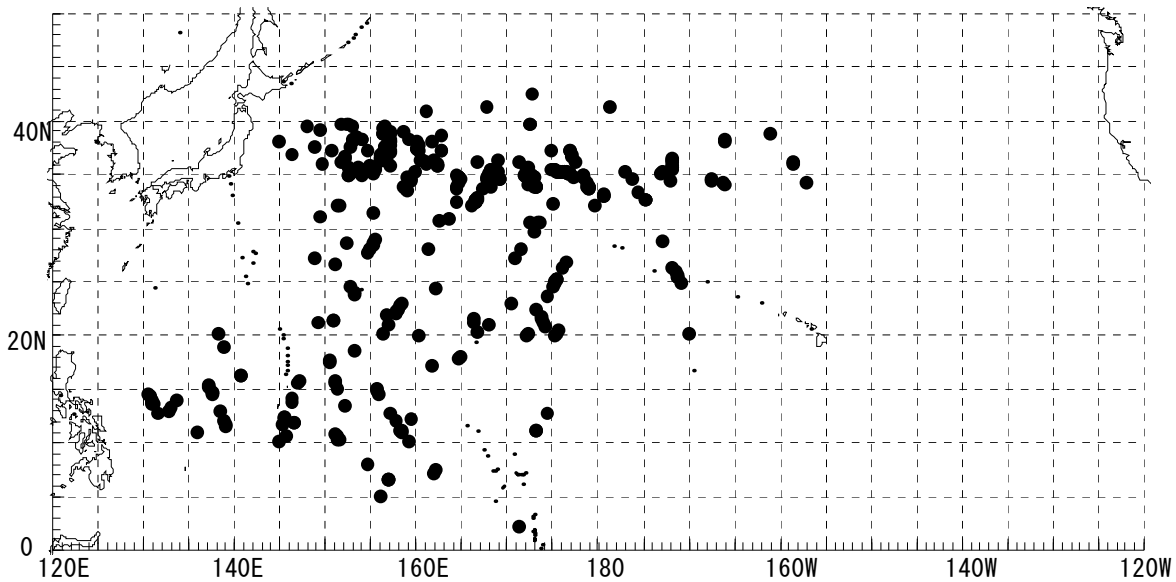


Fig. 5. Primary sighting positions of Bryde's whale during the past sighting surveys in August and September, 1988-1996

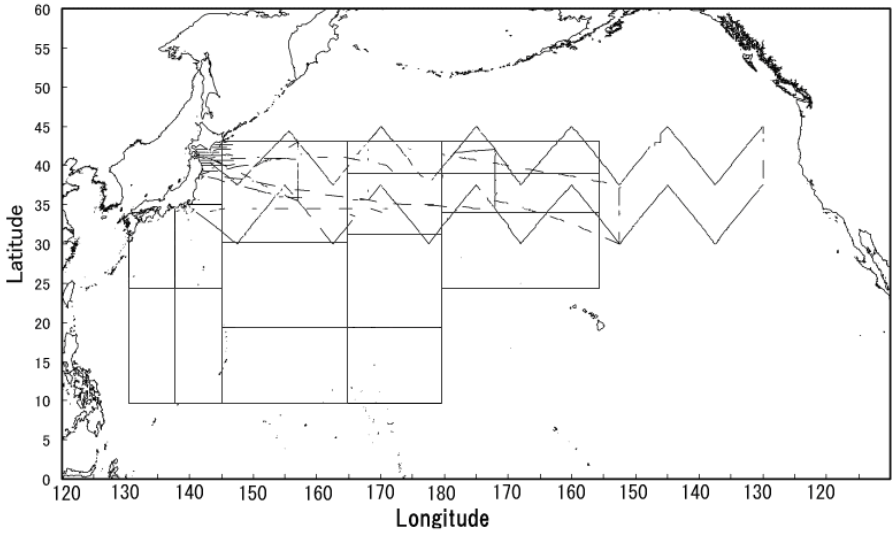


Fig. 6a Pre-detemined cruise track lines on effort during the past sightings surveys in August and September,1988

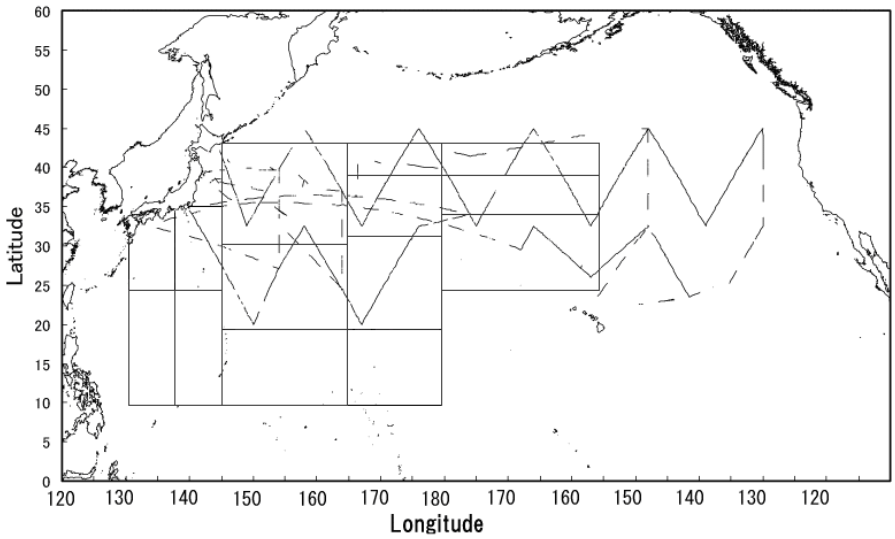


Fig. 6b Pre-detemined cruise track lines on effort during the past sightings surveys in August and September,1989

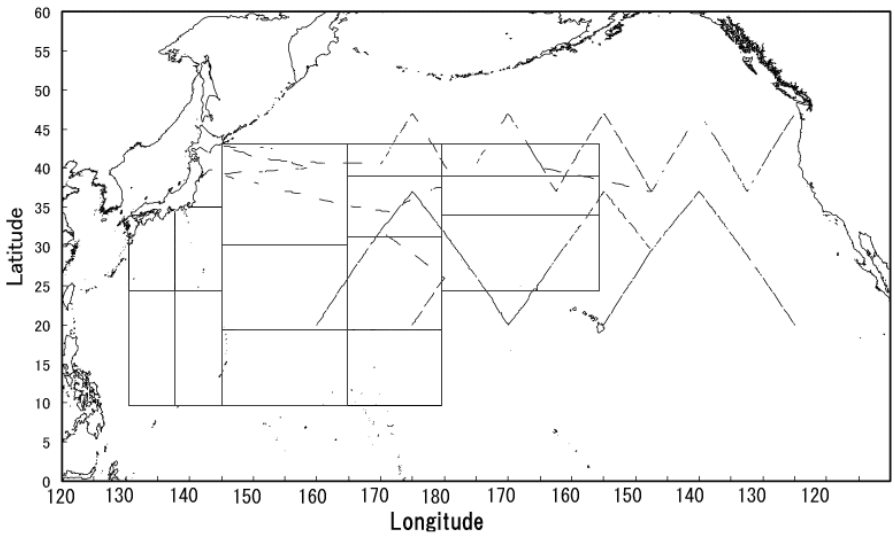


Fig. 6c Pre-detemined cruise track lines on effort during the past sightings surveys in August and September,1990

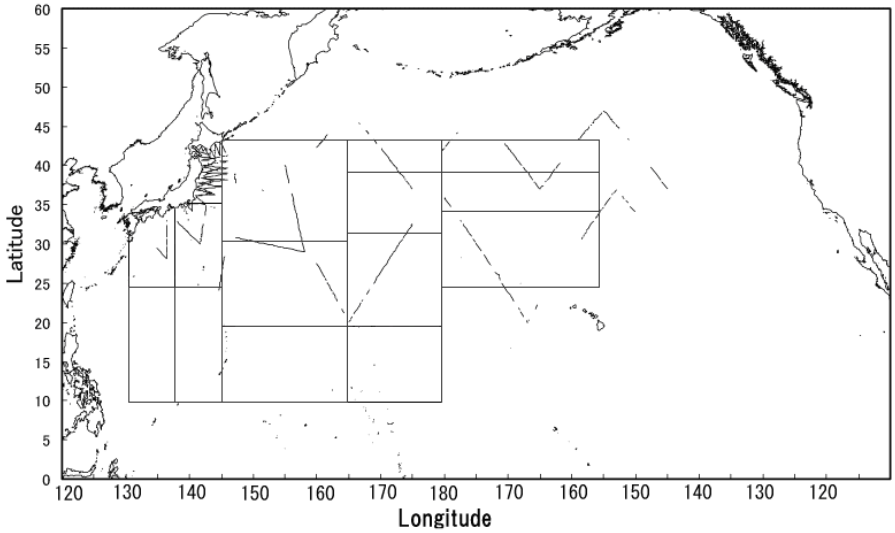


Fig. 6d Pre-detemined cruise track lines on effort during the past sightings surveys in August and September,1991

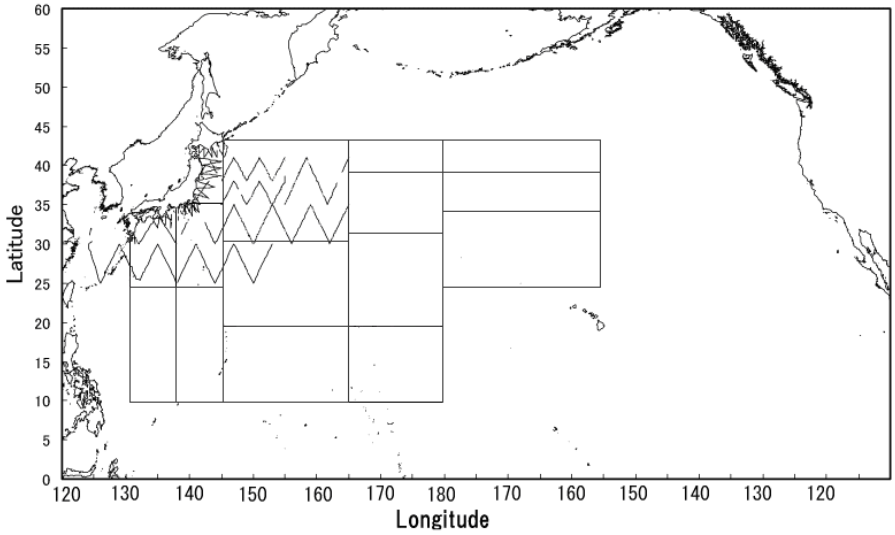


Fig. 6e Pre-detemined cruise track lines on effort during the past sightings surveys in August and September,1992

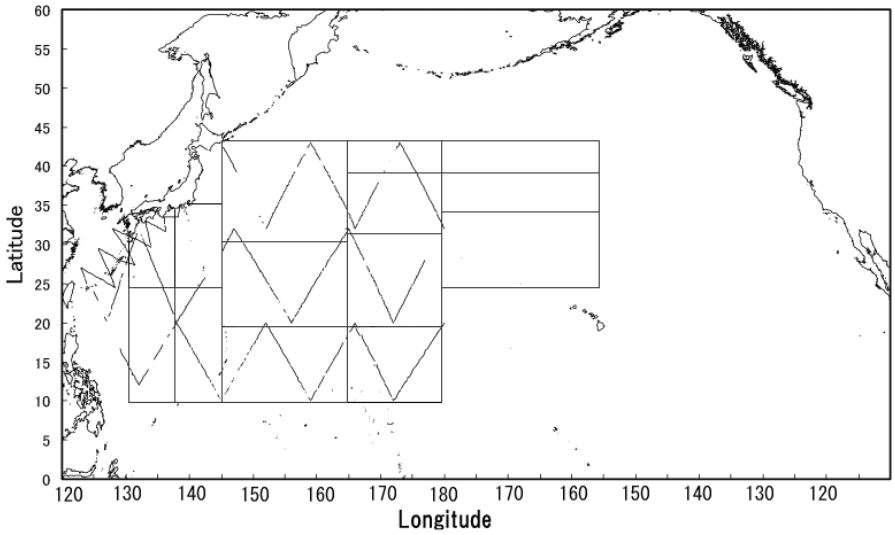


Fig. 6f Pre-detemined cruise track lines on effort during the past sightings surveys in August and September,1993

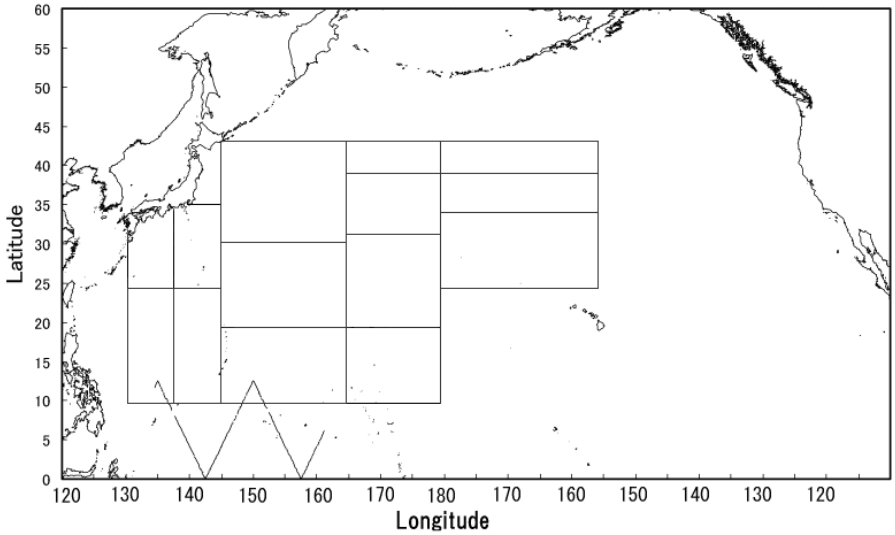


Fig. 6g Pre-detemined cruise track lines on effort during the past sightings surveys in August and September,1994

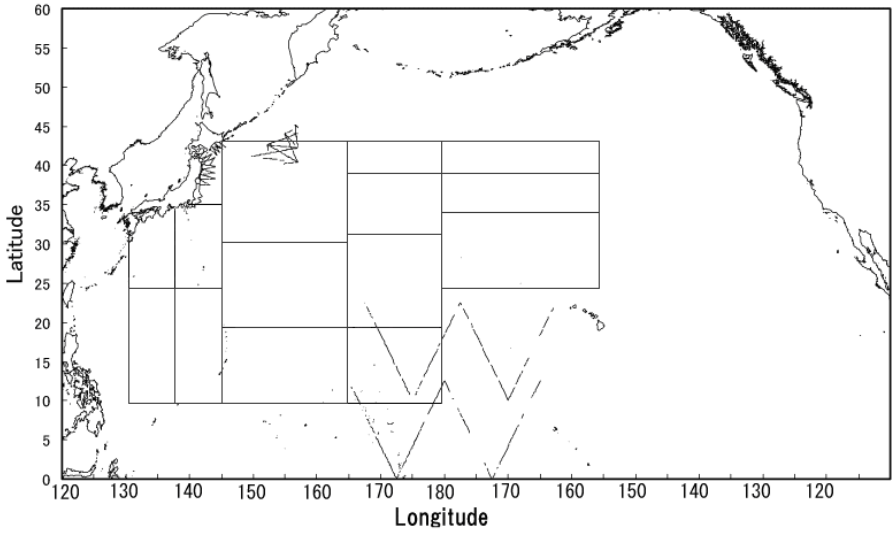


Fig. 6h Pre-detemined cruise track lines on effort during the past sightings surveys in August and September,1995

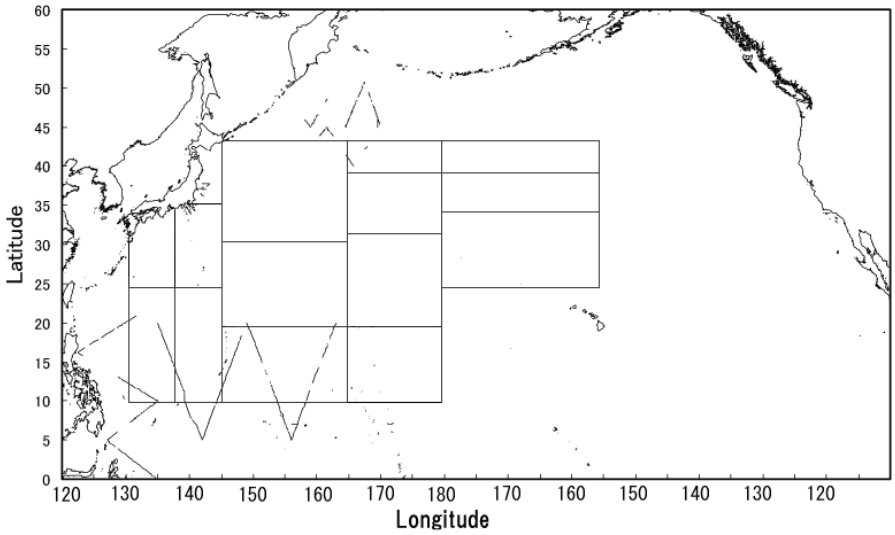


Fig. 6i Pre-detemined cruise track lines on effort during the past sightings surveys in August and September,1996

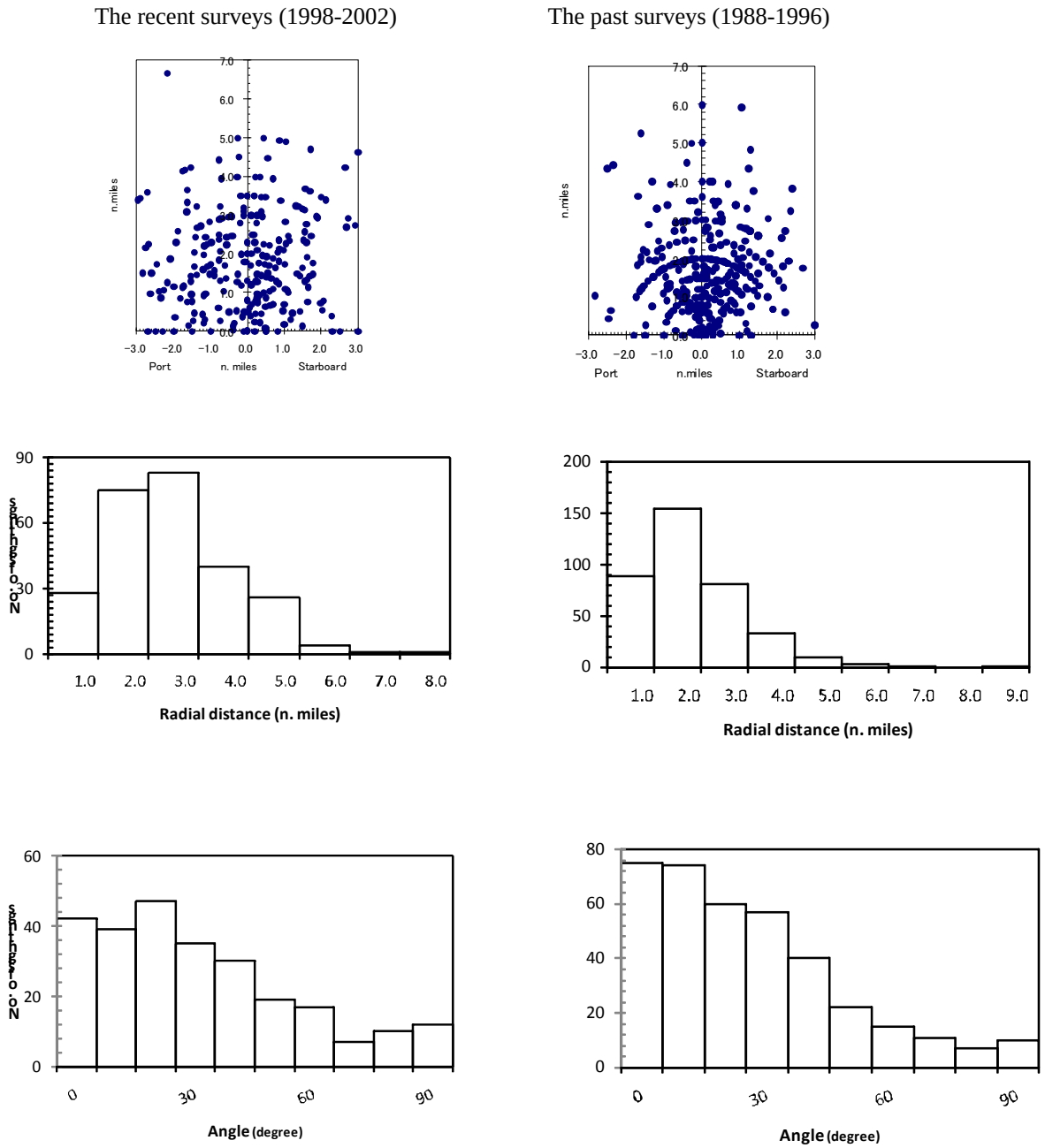
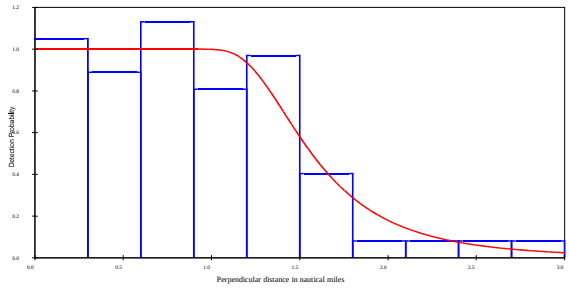
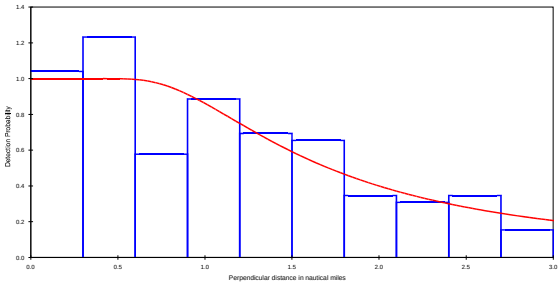


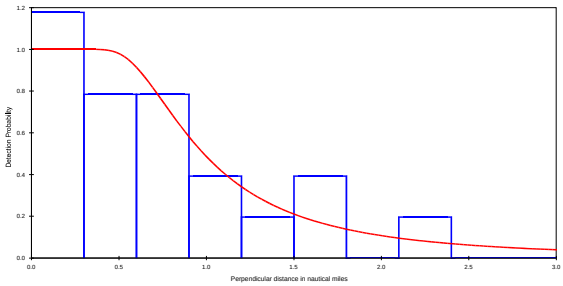
Fig. 7. Plots of the distribution of radial distances and angles before truncation in this estimation. Left figures show the plots in the present surveys (1998-2002) and right one shows in the past surveys (1988-1996). The upper figure shows plots of angle and radial distance. The middle and bottom figures show histograms of radial distances and angle of sightings respectively.



Subarea-1W

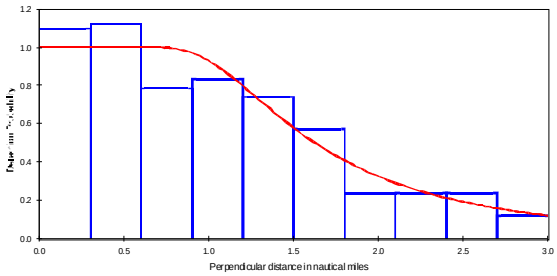


Subarea-1E



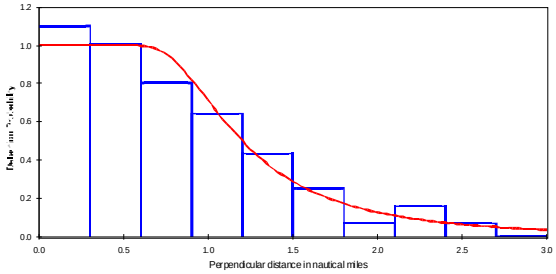
Subarea-2

Fig. 8a. Plot of the detection probability using sighting data in the recent surveys (1998-2002) stratified by sub-area. The sighting mode was constant. The sighting data was truncated at 3.0 n. miles. The Hazard Rate model without adjustments function was used to get f(0) value by Distance 5.0. Upper, middle and low figures show plot of the detection probability in subarea 1W, 1E and 2, respectively.

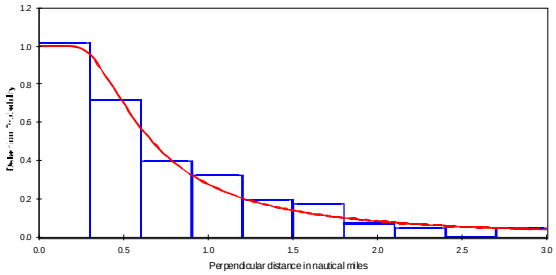


Constant

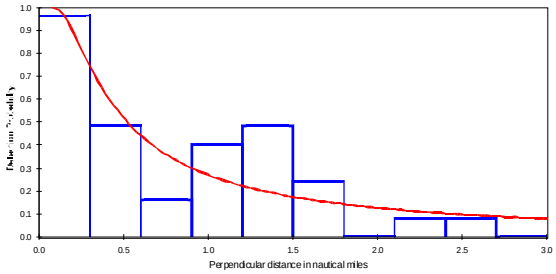
Fig. 8b. Plot of the detection probability using sighting data in the recent surveys (1998-2002) without stratification. The sighting data was truncated at 3.0 n. miles. The Hazard Rate model without adjustments function was used to get f(0) value by Distance 5.0.



Subarea-1W

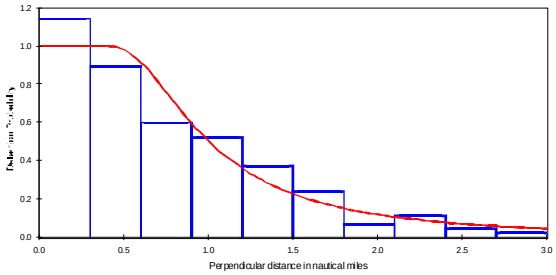


Subarea-1E



Subarea-2

Fig. 8c. Plot of the detection probability using sighting data in the past surveys (1988-1996) stratified by sub-area. The sighting mode was constant. The sighting data was truncated at 3.0 n. miles. The Hazard Rate model without adjustments function was used to get f(0) value by Distance 5.0. Upper, middle and low figures show plot of the detection probability in subarea 1W, 1E and 2, respectively.



Constant

Fig. 8d. Plot of the detection probability using sighting data in the past surveys (1988-1996) without stratification. The sighting data was truncated at 3.0 n. miles. The Hazard Rate model without adjustments function was used to get f(0) value by Distance 5.0.

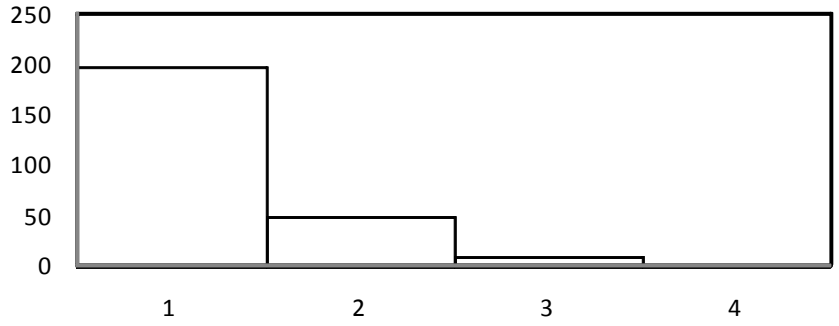


Fig. 9a. Distribution of school sizes of primary sightings for the Bryde's whale in the recent surveys, 1998-2002

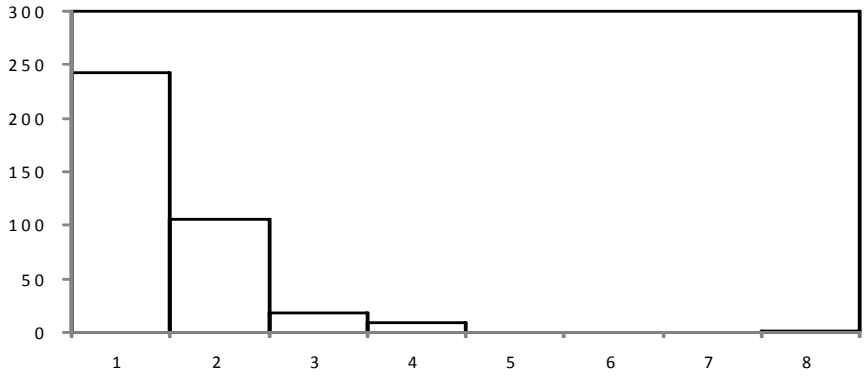


Fig. 9b. Distribution of school sizes of primary sightings for the Bryde's whale in the past surveys, 1996-1998.

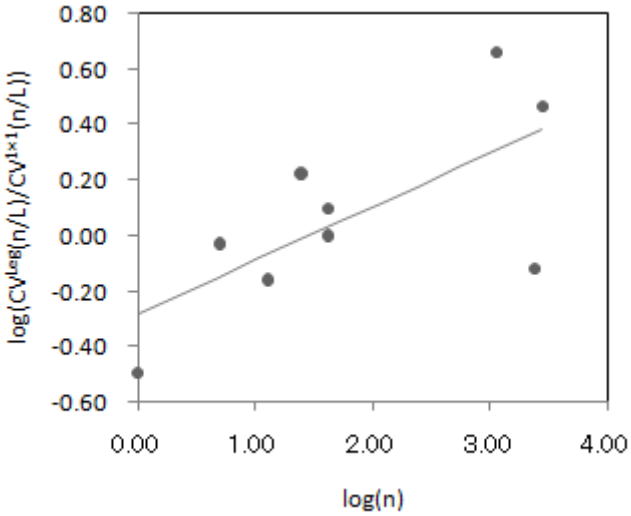


Fig. 10. Plots of ratio of log ($CV^{leg}(n/L)$) to log ($CV^{1\times1}(n/L)$) and log(n) using data on the recent survey (1996-1998). Regression line is log ($CV^{leg}(n/L)$)/ log ($CV^{1\times1}(n/L)$)=0.19477log(n)-0.28076.

APPENDIX

LIST OF CORRESPONDENCE TO THE APPENDIX 8, IN ANNEX D IN THE SC/59 REPORT

This appendix is picked up listed the correspondences to the issues in this paper.

3) OTHER DATA ANALYSIS ISSUES

a. *esw*

It is surprising that the *esw* values listed do not depend on any of the covariates that were examined. The log-likelihood values and the estimates of *esw* for each factor should be included in Table 2. Models in which *esw* depends on area (in this case probably Small Area) should also be compared. It appears that some of the models in Table 2 may not have converged because the negative log-likelihood increases when additional parameters are added to the simplest model; these model fits should be checked.

Though estimation of the *esw* was tried using the program DISTACE, their estimations with covariates did not converge. Hence sighting data was stratified to estimate the detection probability.

The log-likelihood values and the estimates of *esw* for each factor were included in Table 3a and 3b.

The sighting data was stratified by area (sub-area) in addition to research mode, vessel's type, and Beaufort wind scale.

The significant factors were examined using Akaike's information criterion (AIC) (Table 3a and 3b).

The stratified model by sub-area was selected as minimum AIC from them (Table 3a). No stratification and constant of all factors as the second minimum AIC. Though it was no significant difference among them, the *esw* stratified by sub-area was used in this abundance estimation as a base case. Histograms of perpendicular distances and plot of detection probability are shown in Figs. 8a and 8b.

Detection probabilities in the past surveys were estimated as same method as the recent one. The stratified model by sub-area was selected as minimum AIC from them (Table 3b). No stratification and constant of all factors as the second minimum AIC. Though it was no significant difference among them, the *esw* stratified by sub-area was used in this abundance estimation as a base case. Histograms of perpendicular distances and plot of detection probability for stratified by sub-area as the base case and constant in the examination area as the reference case shows in Figs. 8c and 8d, respectively.

b. n/L

The point estimates of n/l change in some cases with the sampling unit in Table 3 – this requires explanation.

The points estimates of n/l were invariable to same cases with the sampling unit (Tables 5a-d and 7a-b).

c. Sampling unit

The implications of using 1 degree sampling units for the calculation of CVs for n/l should be explored further, noting that the CV's increase when the sampling unit is increased from 1 degree to 1 leg. Unless there is a good reason for not doing so, the analyses should be based on taking transect leg as the sampling unit.

The sampling units were used transect legs traversed with effort between way points in the recent survey.

When there was only one replicate line for the block, the CV(n/L) was not calculated from an inter-transect-variation. Assuming the Poisson-like variation for the sightings, $\mathrm{CV}^2(n/L)_i$ is proportional to $1/L_i$. Therefore the CV of the block with only one replicate line was calculated by κ / L_i, where L_i was the effort of the block and calibration factor μ is used

$$\kappa = \sum_{j=1}^{J} \frac{L_j \times \mathrm{CV}^2(\mathrm{n/L})_j}{J}$$

where $j = 1, ..., J$ was the index of the blocks with more than one replicate line.

For the past surveys during 1988 to 1996, CV(n/L) was calculated by using the cells of 1 degree by 1 degree (1×1 cells) as the sampling units because of difficulty on the calculation of leg-based variance. To make two CV(n/L)s between the past and recent surveys comparable for the estimation of unbiased additional variance, we used a calibration factor γ, which was calculated by the following method: let $\mathrm{CV}^{leg}(n/L)_i$ and $\mathrm{CV}^{1deg}(n/L)_i$ denote the leg-based and 1 degree-based CV of n/L of the i th block

calculated from the recent survey data (Table 6). From Table 6, the sample size of sightings tends to affect the calibration factor. We therefore carry out the following linear regression:

$$\log\{CV^{leg}(n/L)_i\} = \log\{CV^{1\deg}(n/L)_i\} + a + b\log(n_i) + \varepsilon$$

where $\log\{CV^{1\deg}(n/L)_i\}$ is an offset term, log(n_i) is the logarithm of sample size in the *i* th block, *a* and *b* are the parameters to be estimated, and ε is a normal deviate which has a normal distribution, $N(0,\sigma^2)$. Then the calibration factor as a function of sample size is given by

$$\gamma(n_i) = \exp(\hat{a} + \hat{b}\log(n_i) + \hat{\sigma}^2/2)$$

and the corrected CV of the *i* th block in the past surveys, $CV^{cor}(n/L)_i$, is calculated by multiplying the 1×1 cell-based CV, $CV^{1\times1}(n/L)_i$, by the calibration factor, $\gamma(n_i)$, where n_i is the sample size of the *i* th block in the past surveys.

The coefficients estimated in the linear regression for the calibration factor were $\hat{a} = -0.28$ and $\hat{b} = 0.19$. The variance $\hat{s}^2$ was 0.071. Using these estimates, the calculated calibration factors (Table 7) and the corrected CVs for each block in the past surveys were provided in Table 8a and 8b. The predicted line showed satisfactory fits (Fig. 10). The model selection by AIC indicated that the model with the influence of sample size was better than that without the influence of sample size (ΔAIC = 3.83). In addition, the hypothesis test whether b = 0 or not also rejected the null hypothesis (b = 0) at the significance level of 5%.

d. It was not possible to cover the northern parts of some blocks

It was not possible to cover the northern parts of some of the strata during the 1998-2002 surveys. The reasons for this should be documented and the implications of only partial coverage of a block examined (e.g. based on sensitivity tests in which boundary of the northern strata are reset to the northern extent of survey coverage). In addition, the results for the initial period could be examined to determine whether there is a gradient in density across the northern strata.

The whole management area was covered through these surveys (Fig.3). But it was covered less than 50 % in the northern parts (north of 39°N) of 1E-H and 2-H block (Fig. 1) during the recent surveys. Because weather conditions in the blocks had not satisfied standards of visibility or sight ability of sighting survey, we could not conduct sighting survey and steamed off effort after waiting there so far as time permits. No sightings of Bryde's whales were in those northern parts. Areas in both reset blocks were 66% and 52% of the original blocks in 1E-H and 2-H respectively. After the northern boundaries reset to 39°N in the both blocks, the sighting rates (n/L) estimated in the both blocks excluding the parts north of 39°N. The sighting rates (CV %) before and after the reset were 0.029 (55.65%) and 0.026 (61.01%) in 1E-H block, and 0.009 (49.96%) and 0.007 (56.31%) in 2-H block respectively. When it was compared with the n/L estimated, it was no significant difference.

In the past surveys, both blocks were adequately covered (Fig.4). As the densities of distribution of the Bryde's whales in the northern part (north of 39°N) were compared with them in the southern part. 0 or one sighting of the Bryde's whale in the northern part in each 1E-H and 2-H block in each surveyed year. Ratio of density of the whales in the northern part to one in the southern part was from 0 to 0.55 and from 0 to 0.08 in each surveyed year in each block. The densities in the north of 39°N were lower clearly than other side. Then the northern boundaries reset to 39°N in the both blocks in the past surveys as well as the recent surveys. Both 1E-H and 2-H blocks were used same definitions of boundaries on this study. Coverage of each block and each mode was over 60% excluding any no sighting blocks after the reset as shown in Tables 5a and 5b. The coverage of each block during abeam closing mode was over 80%.

e. The number of primary sightings

The reasons why the number of animals in Table 2 differs from the total number of primary sightings listed on page 3 should be added to the document.

Total number of primary sightings and animals of the Bryde's whales described on the paper (SC60/PFI2) after truncation at 3 n.miles and the reset of northern boundaries to 39°N. During the recent surveys, 101 schools with 136 animals in the normal closing mode and 150 schools with 190 animals in

the abeam closing mode were sighted. During the past surveys, total primary sightings of Bryde's whales were 355 schools with 520 animals.

f. Table of the like Bryde's whales

A table is needed of the number of initial Bryde's-like sightings that were closed on separated into those whales confirmed to be Bryde's whales, those which were not Bryde's whales, and those which could not be found. Results should be shown separately for passing and closing mode.

Information on the like Bryde's whales is listed in Table 2. The sighting data during the abeam closing mode was used after truncation for the abundance estimation. In the middle and low latitudinal blocks to the south of the summer distribution of sei whales, Initial like Bryde's sightings were closed on separated into 87% of sightings confirmed to be Bryde's whales, 13% as un-identified species. In the high latitudinal blocks (1WE-H, 1E-H and 2-H) where are included in the summer distribution area of sei whales, initial like Bryde's sightings were closed on separated into 73% of sightings confirmed to be Bryde's whales, 8% confirmed sei whales, and 19% un-identified species (Table 2). On the other hand, during normal closing mode, it is not necessary to judge whether like Bryde's whales or not at first sighting, because all sightings are automatically closed.