Abundance estimates for Antarctic minke whales from three completed circumpolar sets of surveys, 1978/79 to 2003/04

T.A. BRANCH[#]
Contact e-mail: tbranch@maths.uct.ac.za

ABSTRACT

Abundance estimates are provided for Antarctic minke whales from the ship-based IDCR-SOWER surveys using the standard distance sampling methodology applied in the past in the Scientific Committee. Agreed methods of pooling strata and of estimating mean school size have changed since the most recent published assessment of these surveys by Branch and Butterworth (2001a). The IDCR-SOWER surveys are grouped into three completed circumpolar sets of cruises: 1978/79–1983/84 (CPI), 1985/86–1990/91 (CPII) and 1991/92–2003/04 (CPIII), which respectively covered 64.3%, 79.5% and 99.7% of the ice-free area south of 60°S. Circumpolar abundance estimates are obtained by summing individual surveys in CPI and CPII (each covered one IWC Management Area), and by combining CPIII surveys (some overlapped) using the 'survey-once' method—by selecting the single survey offering the best or most recent coverage. When calibrated closing and independent observer mode estimates were inverse-variance weighted, circumpolar abundance estimates were 645,000 (CV = 0.143), 786,000 (CV = 0.094) and 338,000 (CV = 0.079) for CPI, CPII and CPIII respectively. These estimates are negatively biased because some Antarctic minke whales are north of 60°S and inside the pack ice during the surveys, and because some whales on the trackline are missed. After simple extrapolation to account for differences in the latitudes surveyed during each circumpolar set and for the increasing proportions of 'like minke' sightings, the ratio of estimates from the three CPs is 0.97:1.00:0.39, echoing previous findings of appreciably lower CPIII estimates. CPIII estimates for individual IWC Management Areas are similarly low, ranging within 18–52% of CPII estimates for Areas I–V, although 159% of CPII for Area VI. Explanations for the appreciably lower abundance estimates include a higher proportion of minke whales within the pack ice and a greater proportion of whales missed on the trackline, but any such hypothesis needs to be reconciled with higher abundance estimates in CPIII than in CPII for blue, humpback, fin, sperm and killer whales based on the same surveys.

INTRODUCTION

The IDCR (International Decade of Cetacean Research) and SOWER (Southern Ocean Whale Ecosystem Research) surveys have been conducted annually under the auspices of the International Whaling Commission (IWC) since the 1978/79 austral summer. These surveys provide the best means of estimating the Southern Hemisphere abundance of Antarctic minke whales (*Balaenoptera bonaerensis*). Sightings vessels on these surveys have completed three separate circumpolar sets of surveys (CPs): CPI from 1978/79 to 1983/84, CPII from 1985/86 to 1990/91 and CPIII from 1991/92 to 2003/04, generally between late December and mid-February. Estimates of abundance from each survey have been presented to the IWC annually (e.g. Burt and Hughes 2006), but assessment methodology has been incrementally improved so that recent and older annual assessments are not comparable. Periodic re-assessments of the entire survey series have been conducted to provide comparable abundance estimates (Haw 1993a, Branch and Butterworth 2001a). Recent re-assessments of the surveys using standard methods have resulted in appreciably lower CPIII abundance estimates compared to CPII (Branch and Butterworth 2001a, Branch 2003), but were based on an incomplete set of CPIII surveys. After the completion of CPIII, preliminary abundance estimates were calculated (Branch 2005a), and are corrected and finalised here.

The standard method of analysing the IDCR-SOWER surveys is based on distance sampling methodology (Buckland *et al.* 1993). A database package called DESS 3.5 (Strindberg and Burt 2004) has been developed to automate the process of extracting survey data and invoking the Distance software program to provide estimates of abundance, and is used here. For the application of alternatives to the standard method, a standard dataset has also been extracted from DESS and is described in Burt (2004). The history of the standard methodology as applied to the IDCR-SOWER surveys is given in Branch and Butterworth (2001a). Subsequently, three main modifications to the methods have been suggested involving changes to recommended pooling, in estimating mean school size, and to calculating the calibration factor, *R*, between closing and independent observer mode density estimates. These changes are detailed in the Methods.

Estimates are presented here for circumpolar abundance and for each IWC Management Area. Survey methods have changed to some extent from one CP to another. Following the methods of Branch and Butterworth (2001a), a simple approach is therefore adopted to provide more comparable estimates from one CP to another by (1) assuming that the density in northern unsurveyed areas is the same as in the corresponding northern strata, and (2) including like minke sightings.

[#] *MARAM (Marine Research Assessment and Management Group), Department of Mathematics and Applied Mathematics, University of Cape Town, Rondebosch, 7701, South Africa.*

Abundance estimates using the standard method assume that all minke whales on the trackline are sighted (Branch and Butterworth 2001a), resulting in negative bias when analysing simulated survey data (Branch 2005b). Alternative estimation methods (Cooke 2001, Bravington 2004, Okamura and Kitakado 2004) have been developed and tested with simulated data (Palka and Smith 2004, Palka 2005); these will hopefully address this source of bias and improve the comparability of CPII and CPIII surveys.

METHODS

The methods used here have been described in all their intricate detail in Branch and Butterworth (2001a). In this paper only an overview of these methods are presented, together with a detailed description of differences compared to the Branch and Butterworth (2001a) analyses (as summarised in Table 1). Preliminary results were presented in Branch (2005a), but since then additional analyses have been completed and some revisions made to the estimates (see Table 2 for details).

Survey design

Strata and cruise tracks

Strata and cruise tracks for the surveys are depicted in Figures 1a-c. Further details of the survey design are contained in more comprehensive references (Branch and Butterworth 2001a, Matsuoka *et al.* 2003). In the first five surveys one vessel remained close to the ice edge while the other alternated between longitudinal and latitudinal transects in a turret-like pattern 60 or more nautical miles from the ice edge, leaving an unsurveyed region between the two vessels. Starting in 1983/84 the design changed, with vessels surveying north and south strata in diagonal zig-zag patterns leaving no unsurveyed regions between strata. In addition, emphasis was placed in CPI and CPII on completing the circumpolar set of surveys in six years but not on completely surveying from the ice edge northwards to 60°S, while in CPIII the surveys took 13 years and completely covered the region from the ice edge northwards to 60°S. In CPI and CPII there was no overlap in longitudinal coverage among surveys, but during CPIII there has been considerable overlap.

Survey vessels

Since 1981/82 the *Shonan Maru* (SM1) and *Shonan Maru 2* (SM2) have been used on every survey, but in earlier surveys (prior to and including the 1986/87 survey) other vessels also conducted some or all of the sighting surveys (Branch and Butterworth 2001a, Matsuoka *et al.* 2003).

Data selected for analysis

Survey modes and activity codes

The surveys have been conducted in closing mode and in independent observer (IO) mode. In closing mode, when a school is sighted, the survey vessel leaves the trackline and closes with the sighting to obtain better species identification and school size estimates. In this mode, two topmen are present in the barrel. In IO mode, an additional observer is present on the IO platform just below the barrel and this observer operates independently from the observers in the barrel. In IO mode, the survey vessel does not leave the trackline when sightings are made.

Many different activity codes have been devised for different types of closing and IO mode effort data. The same activity codes used by Branch and Butterworth (2001a) are used in this analysis, except that survey modes BL and BH are additionally included (Table 3). Search effort is recorded under these codes when a high density of schools in closing mode (BL) or IO mode (BH) results in difficulty in discrimination between schools. Up to and including 1997/98, no search effort was recorded under the BL code, but 0.2% of IO effort was recorded under the BH code, during which time sighting rates were six times higher than the average IO mode sighting rates (Branch and Butterworth 2001a). Including these effort codes therefore removes a slight negative bias present in the Branch and Butterworth (2001a) analyses. Note that the standard dataset used for recent alternative analytical methods does include effort and sightings recorded under BL and BH codes (Burt 2004).

Species codes

Minke or ‘like minke’ sightings may be recorded in DESS 3.5 under the following codes, 04: definitely Antarctic minke, 39: like minke, i.e., probably a minke but not sure; 74: definitely dwarf minke; 90: definitely minke and probably dwarf minke, but not sure; 91: definitely minke, but unsure whether Antarctic or dwarf; 92: definitely minke and probably Antarctic minke, but not certain (Branch and Ensor 2001, Matsuoka *et al.* 2003).

The previous analysis (Branch and Butterworth 2001a) followed the recommendations of Branch and Ensor (2001) in assuming that codes 04, 90, 91 and 92 represented Antarctic minke whales, and that code 39 represented like minke sightings. Although species code 90 (minke, probably dwarf minke) was included for comparability with surveys prior to 1997/98, this decision now seems questionable, and therefore code 90 has been excluded in these analyses. In practice this has no impact on the results because no code 90 sightings were recorded during primary effort (Table 4).

Duplicate and triplicate sightings

In IO mode, the same school may be sighted from the IO platform, the barrel and the bridge, producing duplicate or triplicate sightings that are assigned a status of ‘definite’, ‘possible’ or ‘remote’ that the same school has been sighted. In this paper, only the first of each 'definite' duplicate or triplicate set is used to obtain abundance estimates, although school size and species identification from associated sightings of the same school may also be incorporated.

Abundance estimation

The standard distance line transect sampling formula was used to obtain abundance estimates:

$$P = \frac{A \cdot \bar{s} \cdot n}{2 \cdot w_s \cdot L} \tag{1}$$

where:

P = uncorrected abundance (no correction for random movement or for whales missed on the trackline)
A = area of the stratum (n.miles^2)
$\bar{s}$ = mean school size
n = number of schools sighted during primary search mode
w_s = effective search half-width for schools (n.miles)
L = primary search effort (n.miles).

The CV for P is calculated from:

$$CV(P) = \sqrt{\left[CV\left(\frac{n}{L}\right)\right]^2 + \left[CV(\bar{s})\right]^2 + \left[CV(w_s)\right]^2} \tag{2}$$

The sampling unit used to estimate the variance of the sighting rate (n/L) was taken to be entire days in CPI, and individual segments of effort divided by changes in survey mode or major course changes in CPII and CPIII. The variance estimate was effort weighted, i.e. given that the survey consisted of i =1, 2, …, k sampling units each of length l_i and with n_i schools sighted, then:

$$CV\left(\frac{n}{L}\right) = \frac{L}{n}\sqrt{\frac{1}{k-1}\sum_{i=1}^{k}\frac{l_i}{L}\left(\frac{n_i}{l_i} - \frac{n}{L}\right)^2}$$
$$n = \sum_{i=1}^{k} n_i \quad \text{and} \quad L = \sum_{i=1}^{k} l_i \tag{3}$$

Effective search half-width

Smeared and truncated sightings data were grouped into bins of 0.1 n.miles to estimate the intercept, $f(y=0)$, of the detection function, which is a probability density function of perpendicular distance, y, from the trackline:

$$\begin{aligned} f(y) &= f(0)g(y) \\ &= f(0)\left[1 - \exp\left(-\left[\frac{y}{a}\right]^{-b}\right)\right] \end{aligned} \tag{4}$$

where $g(y)$ is the probability that a school at a perpendicular distance y from the trackline will be sighted, and $a \geq 0.0001$ n.miles and $b \geq 1$ are parameters to be estimated. It is assumed that $g(0) = 1$, i.e. that all schools on the trackline are sighted.

Mean school size

School size estimates are based on confirmed sightings in closing mode only. Confirmed sightings are those sightings where the survey vessel was close enough to the school for observers to estimate the school size reliably. The mean of these sightings is known to be biased because large schools are more visible than small schools. Previously, Branch and

Butterworth (2001a) used the method proposed by Buckland *et al.* (1993) to correct for this bias: either the regression estimate at $y = 0$ of the $\ln(s)$ vs. $g(y)$ regression, or the mean school size within 1.5 n.miles was used. The latter was preferred if the regression was not significant at the 15% level, if the estimated school size was less than one or the correlation between $\ln(s)$ and $g(y)$ was positive (indicating large schools were inexplicably *less* visible further from the trackline). A revised version of this rule is adopted in this paper, following suggestions made by Brandão *et al.* (2001) and adopted by the Scientific Committee[1] (IWC, 2002, p.196–7), and subsequently implemented in DESS (Strindberg and Burt 2004). They suggested that the regression method should be used regardless of the significance level, unless the estimated school size is less than one or the correlation between $\ln(s)$ and $g(y)$ is positive, in which case the mean school size within 0.5 n.miles (and not 1.5 n.miles) is used.

Number of schools sighted

To account for the rounding of angle and distance measurements by observers, these data were smeared using Method II of Buckland and Anganuzzi (1988). The smeared data were truncated at 1.5 n.miles, which excluded about 5% of the sightings. The number of sightings remaining after smearing and truncation is denoted n_s and includes sightings with both confirmed and unconfirmed school sizes.

Pooling to estimate effective search half-width and mean school size

Small sample sizes occurred in certain strata on some surveys, requiring the pooling of sightings to estimate search half width and mean school size. Several alternatives have been proposed for pooling strata. In a typical recent survey, two vessels (SM1 and SM2) survey four strata: SM1 might survey the southwest (SW) and northeast (NE) strata, and SM2 the northwest (NW) and southeast (SE) strata. In this example, pooling could be north vs. south (NE and NW, SE and SW), by vessel (SW and NE, NW and SE), all strata, or a smaller subset of strata. Conventionally the same pooling is used for closing mode estimates and for IO mode estimates. In line transect analyses it is generally recommended that all combinations of pooling are considered, and then Akaike's Information Criterion (AIC; Akaike 1973) used to find which pooling option best fits the perpendicular distance distributions. Annual survey estimates presented to the IWC have followed this approach (e.g. Burt and Hughes 2004, 2005, 2006). However, Branch and Butterworth (2001a) pointed out several problems with this approach in the IWC surveys, mostly due to AIC recommendations differing for closing and IO mode, a philosophical desire for minimal pooling, and particular AIC pooling recommendations that seemed idiosyncratic. In their analyses, they recommended not pooling if there were more than 15 confirmed and unconfirmed sightings in a stratum, and if there were fewer sightings, then pooling by vessel (Branch and Butterworth 2001a). Subsequently, Hakamada and Matsuoka (2002) suggested that it made more sense to pool by north vs. south since sighting conditions were generally poorer in the northern strata. Their re-analysis pooling north vs. south showed that individual survey estimates may change by up to 47%, that the sum of the CPII estimates increased by 4% and the sum of the CPIII estimates (up to 1997/98) by 8%. A further analysis of AIC values for the options of north vs. south, by vessel, separate, and all strata pooled (Branch and Butterworth 2002), supported pooling by north vs. south instead of by vessel, and suggested the following rules for pooling:

(1) If there are at least 10 confirmed sightings in closing mode and at least 15 confirmed and unconfirmed sightings in both closing and IO mode, then that stratum should not be pooled with other strata.

(2) If there are too few sightings, then pool north vs. south in such a way as to minimize the number of pooling steps.

(3) If there are still too few sightings, or the distribution of perpendicular sightings is poorly fitted by the detection function, then consider further pooling of strata.

The threshold number of sightings represents a balance between minimizing pooling while still being able to fit the detection function to the perpendicular distance data, but is still admittedly an *ad hoc* rule. The Scientific Committee did not recommend which pooling method to use, but did endorse the view that pooling should not be based solely on statistical criteria but also on biological or environmental evidence (IWC 2003, p.33). In this revision the pooling suggestions of Branch and Butterworth (2002) are followed for the 1978/79 to 1997/98 surveys, and their general rules applied for pooling the 1998/99 to 2003/04 surveys.

Averaging where strata were surveyed by two vessels

When two vessels surveyed the same stratum, the two density estimates are combined using an effort-weighted average (Branch and Butterworth 2001a).

Factors applied to the uncorrected abundance estimate

At least two factors are not taken into account in producing the uncorrected abundance estimates. The first is the correction factor for whale movement, which has been estimated to be m = 0.985 (CV = 0.0). The second is the correction factor $h = g(0)^{-1}$ to account for the number of schools on the trackline that are missed. There is no agreed-upon value for h (which

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[1] On p. 196, the meeting report states that Brandão *et al*. (2001) examined the method of Branch and Butterworth (2001), resulting in a recommendation from the IA Subcommittee that the Brandão *et al.* method should be implemented in DESS. But on p. 197 and in the SC report on p. 31, this decision is transcribed incorrectly, and states that the modified approach of Branch and Butterworth (and not Brandão *et al.*) be adopted. Regardless of this confusion, the Brandão *et al*. method is the one now implemented in DESS and used in current analyses.

is likely to be stratum-specific), although several new methods have been proposed which will likely provide realistic estimates (Cooke 2001, Bravington 2004, Okamura and Kitakado 2004). In this paper the uncorrected abundance estimates are presented, and not the corrected estimates $N = mhP$.

Combining IO and closing mode abundance estimates

The IO survey mode should be considered the standard for abundance estimation. This is partly because there is an additional observer in IO mode, and partly because in closing mode, the process of closing on sightings has the potential to non-randomly sample high-density areas. Conventionally, closing mode abundance estimates (P_{closing}) have therefore been converted into pseudo-IO abundance estimates using a calibration factor R which represents the ratio between closing mode and IO mode school densities. The final abundance estimate (P_{average}) is obtained by combining the IO (P_{IO}) and pseudo-IO (P_{pseudo}) abundance estimates through inverse-variance weighting:

$$\begin{aligned}
&P_{\text{pseudo}} = P_{\text{closing}} / R\\
&CV\left(P_{\text{pseudo}}\right) = \sqrt{CV\left(P_{\text{closing}}\right)^2 + CV\left(R\right)^2}\\
&a = \frac{\text{var}\left(P_{\text{IO}}\right)}{\text{var}\left(P_{\text{pseudo}}\right) + \text{var}\left(P_{\text{IO}}\right)}\\
&b = \frac{\text{var}\left(P_{\text{pseudo}}\right)}{\text{var}\left(P_{\text{pseudo}}\right) + \text{var}\left(P_{\text{IO}}\right)}\\
&P_{\text{average}} = a \cdot P_{\text{pseudo}} + b \cdot P_{\text{IO}}\\
&CV\left(P_{\text{average}}\right) = \frac{\sqrt{a^2\ \text{var}\left(P_{\text{pseudo}}\right) + b^2\ \text{var}\left(P_{\text{IO}}\right)}}{P_{\text{average}}}
\end{aligned} \tag{5}$$

Value of R used in analyses

The estimate of R has traditionally been obtained from an inverse-variance weighted average of the individual R_i ratios between closing mode and IO mode school density estimates for all strata (Borchers and Butterworth 1990):

$$\begin{aligned}
&R_i = \frac{D_{i,\text{closing}}}{D_{i,\text{IO}}}\\
&CV(R_i) = \sqrt{CV(D_{i,\text{closing}})^2 + CV(D_{i,\text{IO}})^2}\\
&\text{var}(\ln R_i) = \ln[CV(R_i)^2 + 1]\\
&V_i = \frac{[\text{var}(\ln R_i)]^{-1}}{\sum_j [\text{var}(\ln R_j)]^{-1}}\\
&R = \exp\left[\sum_i V_i \ln R_i + \frac{1}{2\sum_i [\text{var}(\ln R_i)]^{-1}}\right]\\
&CV(R) = \sqrt{\exp\left(\frac{1}{\sum_i [\text{var}(\ln R_i)]^{-1}}\right) - 1}
\end{aligned} \tag{6}$$

When strata were pooled to estimate mean school size and the effective search half-width, the ‘super-strata’ method of Haw (1991b) is used to obtain the area-weighted average density of schools for closing and IO mode for the $i = 1..m$ strata involved:

$$W_i = \frac{A_i}{\sum_j A_j}$$

$$\bar{D} = \frac{1}{2w_s} \sum_i W_i \left(\frac{n}{L}\right)_i \tag{7}$$

$$CV(\bar{D}) = \sqrt{CV(w_s)^2 + \frac{\sum_i \left[W_i^2 \left(\frac{n}{L}\right)_i^2 CV\left(\frac{n}{L}\right)_i^2 \right]}{\left[\sum_i W_i \left(\frac{n}{L}\right)_i \right]^2}}$$

Estimates of *R* have increased over time from 0.751 (CV = 0.152) for the 1985/86 to 1988/89 surveys (Haw 1991a), to 0.826 (CV = 0.089) when updated to 1997/98 (Branch and Butterworth 2001a) and to 0.872 (CV = 0.075) when the surveys to 2004/05 were included (Burt and Hughes 2006). This latest estimate is not significantly different from zero.

Previous estimates suggested that values of *R* were generally similar between CPII and CPIII, but were lower (0.758, CV = 0.083) when 'like-minke' sightings were included in the abundance estimates (Brandão and Butterworth 2002). Those authors suggested that different *R* estimates should be used when like minke whales are included. In addition they suggested, and the Scientific Committee concurred, that different estimates of *R* should be used for CPII and CPIII so that historical abundance estimates did not have to be continually updated with each new estimate of *R* (IWC, 2003, p.41-42).

In this assessment, updated estimates of *R* are produced based on the revised school density estimates. Estimates are calculated for all surveys and separately for CPII and CPIII. Where like minke sightings are included in the abundance estimates, *R* is re-estimated for CPII and CPIII. When converting CPI closing mode abundance estimates to pseudo-IO mode, the CPII estimates are used.

Comparison of abundance estimates from each circumpolar set of surveys

'Survey-once' circumpolar estimates

Circumpolar abundance estimates can be obtained easily for the CPI and CPII surveys since each individual survey covered a complete IWC Management Area, but it is harder to produce a circumpolar estimate for the CPIII surveys, which generally covered only a portion of one Management Area, sometimes overlapped other CPIII surveys, and occasionally covered two Management Areas. Two methods have been suggested for obtaining circumpolar estimates from the CPIII surveys: the 'survey-once' and 'combined-survey' methods (Branch and Ensor 2004, Branch 2005c). Results here are presented only for the 'survey-once' method that uses the most recent (or most complete) survey in each longitudinal band. This method is the easier of the two to implement, but discards survey data where portions of Management Areas have been surveyed on multiple occasions.

Comparable circumpolar abundance estimates

To obtain comparable circumpolar abundance estimates, several major features of the circumpolar sets should be taken into account. These features include the different survey design in CPI, the increase in the percentage of 'like minke' sightings over time, and the lack of survey extension northwards to 60°S in most CPI and CPII surveys. Two methods are used to provide more comparable results. "Comparable area" estimates make the assumption that the densities in the unsurveyed regions between the northern strata and 60°S are the same as in the corresponding northern strata, and also proportionally decrease estimates in strata that extend north of 60°S (Branch and Butterworth 2001a). This assumption likely introduces some positive bias in the comparable CPII estimates because the density of minke whales decreases further from the ice edge. The second approach towards more comparable results is to repeat the comparable-area methods but additionally include like minke sightings. When like minke sightings are included, *R* is re-estimated for CPII and CPIII.

Estimates for individual IWC Management Areas

The 'survey-once' method was used to obtain abundance estimates for each Management Area in CPIII (Branch and Ensor 2004, Branch 2005c) for comparison with estimates from CPI and CPII. The choice of surveys was the same as used for the 'survey-once' circumpolar estimate, except that strata that overlapped two Management Areas were divided so that effort and sightings were allocated to the appropriate Management Areas.

RESULTS

IDCR-SOWER surveys covered approximately 64.3%, 79.5% and 99.7% of the ice-free area south of 60°S in CPI, CPII and CPIII respectively. During the 1978/79–2003/04 surveys, 10,024 minke and like minke sightings were recorded during primary search effort (Table 4). The proportion of like minke sightings increased from CPI (0.1%) to CPII (11.1%) and again to CPIII (17.7%), although note that CPI surveys were conducted in closing mode only (unlike the alternating closing and IO mode in CPII and CPIII) resulting in few like minke sightings. Estimates for individual components making up the abundance estimates for each survey are presented for closing mode (Table 5a-c) and IO mode (Table 5d-e). Component estimates that seemed unusual were examined more closely. The highest mean school size (10.11) in the pooled ES1 and EBAY strata in 1986/87 is due to vessel SM1 recording a number of large schools (including 100 and 120 minke whales) on 28/01/1987. The cruise report makes reference to large school sizes recorded that year (Anon 1987). The CV is high (0.946) for estimated search half width from closing mode for the pooled ES, WN and EN strata in 1987/88. This was due to a poor fit of the detection function to the many sightings recorded on the trackline in those strata.

Estimates of R for all surveys were 0.815 (CV = 0.075) and decreased to 0.750 (CV = 0.073) when like minke sightings were included (Tables 6–7). When calculated separately for CPII and CPIII, the CPII estimates of R were lower: 0.761 vs. 0.872, and 0.717 vs. 0.784 when like minke sightings were included.

Inverse-variance weighted abundance estimates for each survey (Table 8) were fairly similar to those in the original assessments and in Branch and Butterworth (2001a). The inverse-variance weighted abundance estimates for each survey are compared under the modifications necessary to obtain ‘survey-once’, comparable areas, and comparable areas plus like minke circumpolar abundance estimates (Table 8). Circumpolar abundance estimates under the ‘survey-once’ method were 645,000 (CV = 0.143), 786,000 (CV = 0.094) and 338,000 (CV = 0.080) for CPI, CPII and CPIII respectively (Table 9). The ratio of CPI:CPII:CPIII was 0.82:1:0.43. When adjusted for comparable areas, the circumpolar abundance estimates were 931,000 (CV = 0.155), 970,000 (CV = 0.109) and 339,000 (CV = 0.079) respectively, with CPI:CPII:CPIII ratios of 0.96:1.00:0.35 (Table 10). When like minke sightings are additionally included in comparable-area estimates, circumpolar abundances were 989,000 (CV = 0.154), 1,022,000 (CV = 0.117) and 402,000 (CV = 0.072), with CPI:CPII:CPIII ratios of 0.97:1.00:0.39.

Inverse-variance abundance weighted estimates for each IWC Management Area are given in Table 11. Comparable-area estimates in CPIII were lower than those in CPI and in CPII for all IWC Management Areas except for Area VI where the CPIII estimate was higher than in CPII (CPI:CPII:CPIII ratio 2.15:1.00:1.59). Estimates of abundance were also lower when closing mode and IO mode estimates were considered separately, and when like minke sightings were included. The ratio of CPIII:CPII for Areas I to V ranged from 0.18–0.52 for comparable areas plus like minke sightings.

DISCUSSION

The circumpolar estimates of abundance using the survey-once method are 645,000 (CV = 0.143), 786,000 (CV = 0.094) and 338,000 (CV = 0.080) for CPI, CPII and CPIII respectively. These estimates incorporate important refinements and arise from a larger dataset than the set of estimates agreed on by the Scientific Committee in the 1991 Comprehensive Assessment. At that time the most recent agreed estimates for each Area summed to 760,000 (CV = 0.098) but were based on surveys covering only 79.5% of the ice-free region south of 60°S, relied on estimation methodology that has now been revised, and referred to surveys spanning two different CP sets (1982/83–1988/89, midpoint 1985/86). In comparison, the most recent circumpolar estimate in this paper is calculated using the latest circumpolar set of surveys (CPIII: 1992/93–2003/04, midpoint 1998), and applies to an area covering 99.7% of the ice-free area south of 60°S.

These estimates are minimum estimates for the entire Southern Hemisphere population of minke whales. The estimates are known to be negatively biased because not all minke whales migrate south of 60°S during the period of the surveys, some minke whales remain within the pack ice out of the reach of the survey vessels, and some minke whales on the trackline are not detected by the survey vessels.

Estimates of comparable-area circumpolar estimates of abundance from the completed CPIII surveys were significantly lower than those obtained from the CPII surveys (CPIII:CPII = 0.35), and this significant difference remained when like minke sightings were included (CPIII:CPII = 0.39). This ratio is lower than previous estimates of 0.55 for closing mode and 0.45 for IO mode from the 1991/92 to 1997/98 surveys (Branch and Butterworth 2001a) and an inverse-variance weighted ratio of 0.432 from the 1991/92 to 2000/01 surveys (Branch 2003). The lower ratio in this paper is due to the inclusion of more surveys in the estimate, changes in analysis methods, and the correction of stratum areas particularly for the 2002/03 survey (Table 2). CPIII estimates for individual IWC Management Areas range between 18% and 52% of CPII estimates except for Area VI (159%). Abundance estimates (comparable areas + like minke) are less than 50,000 for Areas I, II, III and IV in CPIII, while in CPI and CPII the comparable abundance estimates were never less than 50,000 for any IWC Management Area.

Possible reasons for appreciably lower CPIII minke estimates have been extensively debated in previous Scientific Committee reports; a summary is provided in Branch (2006b) and therefore a full discussion is not included here. Major sources of uncertainty are the proportion of minke whales residing in the pack ice where vessels are unable to survey (e.g. Murase and Shimada 2004), and the possibility that a greater proportion of minke whales on the trackline were missed in CPIII. New methods of analysing the surveys are being developed that should address the latter possibility (Cooke 2001, Bravington 2004, Okamura and Kitakado 2004). While a number of factors other than a decline in actual abundance may have resulted in appreciably lower abundance estimates, any such explanation needs to be reconciled with the fact that estimates for other species have increased from CPII to CPIII, given that these estimates have been obtained using the same methodology and based on data obtained from the same surveys. Estimates for blue whales more than doubled (Branch and

Rademeyer 2003), estimates for humpback whales have more than tripled (Branch 2006a), and estimates for fin, sperm and killer whales all increased from CPII to CPIII (Branch and Butterworth 2001b).

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Table 1. Differences in the methods used compared to Branch and Butterworth (2001).

Topic	Branch and Butterworth (2001)	This paper	Implications
Activity codes	BA, BC, BR, SE, BK, BI, BO, BU, BQ	Additionally included BH and BL codes (high density of schools)	Zero closing but 0.2% of IO effort in these codes, but sighting rate six times greater; corrects small negative bias
Species codes	Minke 04, 90, 91, 92 like minke 39	Excluded code 90: minke, probably dwarf minke	Zero sightings of code 90, results unaffected
Estimated school size	If significant at 15%, correlation negative, and mean greater than one then regression method else mean within 1.5 n.miles	Regression method regardless of significance, but if positive correlation or school size less than one, then mean within 0.5 n.miles	Reduced CPI estimates by 5%, CPII by 7% and CPIII (to 1997/98) by 1% (Brandão *et al.* 2001)
Pooling	When necessary, strata surveyed by same vessel are pooled	When necessary, northern strata pooled and southern strata pooled	Increased sum of CPII estimates by 4% and CPIII (to 1997/98) by 8% (Hakamada and Matsuoka 2002)
Closing:IO density ratio (*R*)	Single estimate obtained for CPII and CPIII combined	Separate estimates obtained for CPII and CPIII	Increases comparable areas CPIII:CPII ratio from 0.35 to 0.36
DESS software	Version 3.0	Version 3.5	Included 1998/99 to 2003/04 surveys and new school size estimation method

Table 2. Corrections and additions in this paper compared to the preliminary results in Branch (2005a).

Topic	Branch (2005a)	This paper	Implications
Ice-free area surveyed south of 60°S	63.1% (CPI), 79.5% (CPII), 99.9% (CPIII)	64.3% (CPI), 79.5% (CPII), 99.7% (CPIII)	No real implications for abundance estimates
Ratio, *R*, of closing:IO density estimates	0.826 (CV=0.089) for all surveys	0.815 (CV=0.075) for all surveys; 0.761 (CV=0.109) for CPII; 0.872 (CV=0.104) for CPIII	Increases the CPIII:CPII ratio from 0.35 to 0.36 when separate *R* values used for CPII and CPIII
Like minke sightings	Not included in comparable circumpolar abundance estimates	Included in comparable circumpolar abundance estimates	Increases CPIII:CPII ratio from 0.35 to 0.39
Area of ES stratum 1996/97	67,072 n.miles^2	52,534 n.miles^2	Decreases 1996/97 inverse-variance weighted estimate from 36,798 to 35,783, reducing CPIII by ~0.3%.
Area of W1S and W2N strata in 2002/03	101,237 n.miles^2 (W1S) 22,128 n.miles^2 (W2N)	22,128 n.miles^2 (W1S) 101,237 n.miles^2 (W2N)	Reduces CPIII by ~6%
Comparable areas 1987/88	Abundance assigned to incorrect strata for comparable areas	Error corrected	Increases CPI by 3.2%
Unsurveyed area N of WNE stratum in 1996/97	5,000 n.miles^2	14,691 n.miles^2	Increases CPII by 0.1%

Table 3. Summary of activity codes in closing and IO mode in the IDCR/SOWER surveys. Changes introduced in the analyses of this paper (compared to those in Branch and Butterworth 2001) are indicated in bold.

Survey mode	Activity code	Description	Branch and Butterworth (2001)	This paper
Closing	BA	Ice navigation reduces effective search effort	Included	Included
Closing	BC	Searching on the trackline	Included	Included
Closing	BR	Returning to trackline after closing on a sighting	Included	Included
Closing	SE[1]	Closing mode, no distinction between BC and BR	Included	Included
Closing	BK[2]	Closing with independent observer tracking (1987/88 only)	Included	Included
Closing	BL	High density of schools causes difficulty in discriminating between schools	Excluded	**Included**
Closing	BB	Blue whale mode, special emphasis on finding and tracking blue whales	Excluded	Excluded
IO	BI	Ice navigation reduces effective search effort	Included	Included
IO	BO	Standard IO mode	Included	Included
IO	BU	Cue counting from bridge during BO mode (1986/87 only)	Included	Included
IO	BQ	Passing with independent observer tracking (1987/88 only)	Included	Included
IO	BH	High density of schools causes difficulty in discriminating between schools	Excluded	**Included**
IO	BP	Passing mode, no independent observer	Excluded	Excluded

[1] Used in CPI then split into BC and BR codes for CPII and CPIII surveys.
[2] Formerly BB mode but renamed when blue whale mode was introduced under BB code.

Table 4. Number of sightings recorded under each of the minke species codes during primary search effort obtained from the standard dataset (Burt 2004). Definite duplicates and triplicates were removed. Prior to 1985/86 surveys were conducted in closing mode only; thereafter survey legs alternated between closing and IO mode. Species codes 90, 91, and 92 were introduced in 1997/98.

Survey	Antarctic minke (04)	Minke, probably dwarf (90)	Minke, uncertain (91)	Minke, probably Antarctic (92)	Like minke (39)	Total	% like minke
1978/79	569	–	–	–	–	569	0.0%
1979/80	460	–	–	–	–	460	0.0%
1980/81	639	–	–	–	2	641	0.3%
1981/82	497	–	–	–	1	498	0.2%
1982/83	611	–	–	–	–	611	0.0%
1983/84	196	–	–	–	–	196	0.0%
1985/86	984	–	–	–	116	1,100	10.5%
1986/87	655	–	–	–	64	719	8.9%
1987/88	272	–	–	–	48	320	15.0%
1988/89	434	–	–	–	20	454	4.4%
1989/90	498	–	–	–	96	594	16.2%
1990/91	150	–	–	–	33	183	18.0%
1991/92	490	–	–	–	119	609	19.5%
1992/93	307	–	–	–	49	356	13.8%
1993/94	229	–	–	–	75	304	24.7%
1994/95	224	–	–	–	51	275	18.5%
1995/96	162	–	–	–	41	203	20.2%
1996/97	145	–	–	–	47	192	24.5%
1997/98	115	–	43	–	41	199	20.6%
1998/99	94	–	27	–	60	181	33.1%
1999/00	42	–	4	–	10	56	17.9%
2000/01	125	–	54	–	27	206	13.1%
2001/02	66	–	29	1	36	132	27.3%
2002/03	158	–	64	1	40	263	15.2%
2003/04	480	–	162	4	57	703	8.1%
Total	8,602	0	383	6	1,033	10,024	10.3%

Table 5a. Abundance estimates of Antarctic minke whales obtained from **CPI** surveys in **closing mode**. Column headings are: A = stratum area (n.miles^2), N_L = number of transects, n_s = schools sighted after truncation at 1.5 n.miles and smearing, L = primary search effort (n.miles), Pool = pooling of strata in a survey to estimate search half width and mean school size, w_s = effective search half-width (n.miles) , E[s_{sc}] = estimated mean school size (based on confirmed schools in closing mode only, D_w = density of whales, P = abundance estimates for individual strata, Ave = strata surveyed by two vessels for which P will be averaged by effort-weighting, Total = total estimated abundance for each survey.

Year	Vessel	Stratum	A	N_L	n_s	L	n_s/L	CV	Pool	w_s	CV	E[s_{sc}]	CV	D_w	P	CV	Ave	Total	CV
1978/79 (IV)	T16	EN	156,766	18	68.0	2155.5	0.032	0.321	1	0.295	0.137	2.75	0.113	0.147	23,099	0.366			
	T16	W1N	39,256	2	9.0	222.2	0.041	0.784	1	0.295	0.137	2.75	0.113	0.189	7,423	0.804	1		
	T16	W1S	20,389	5	54.9	200.6	0.274	0.184	2	0.400	0.328	2.28	0.151	0.779	15,881	0.405			
	T16	W2N	153,914	3	5.0	384.7	0.013	0.298	1	0.295	0.137	2.75	0.113	0.061	9,337	0.347	2		
	T16	W2S	29,600	12	83.7	1073.3	0.078	0.141	3	0.349	0.243	3.25	0.101	0.363	10,752	0.298	3		
	T18	ES	27,571	16	167.0	1436.6	0.116	0.160	4	0.393	0.181	6.52	0.091	0.965	26,599	0.258			
	T18	W1N	39,256	6	35.6	685.3	0.052	0.266	5	0.238	0.341	2.07	0.146	0.226	8,858	0.457	1		
	T18	W2N	153,914	11	25.8	1212.5	0.021	0.363	6	0.530	0.223	2.05	0.131	0.041	6,343	0.446	2		
	T18	W2S	29,600	4	40.8	393.4	0.104	0.222	7	0.314	0.357	1.85	0.124	0.306	9,048	0.438	3	91,444	0.151
1979/80 (III)	K27	ES	41,772	20	166.3	1346.5	0.124	0.194	1	0.254	0.257	2.43	0.088	0.591	24,668	0.334			
	K27	WN	200,724	16	53.0	2014.9	0.026	0.249	2	0.261	0.336	2.10	0.117	0.106	21,311	0.434			
	T11	EN	217,865	20	56.4	2636.7	0.021	0.188	3	0.263	0.516	3.23	0.123	0.131	28,627	0.563			
	T11	WS	33,619	19	138.2	968.2	0.143	0.211	4	0.303	0.214	3.15	0.080	0.742	24,944	0.311		99,549	0.219
1980/81 (V)	K27	EN	208,159	14	77.7	877.3	0.089	0.141	1	0.331	0.378	1.87	0.093	0.251	52,172	0.414			
	K27	ES	98,766	5	54.1	439.6	0.123	0.376	2	0.480	0.371	2.71	0.124	0.347	34,294	0.543	4		
	K27	WS	34,164	17	74.0	698.1	0.106	0.240	3	0.262	0.366	3.14	0.110	0.634	21,676	0.451			
	T11	ES	98,766	21	293.1	2133.3	0.137	0.244	4	0.531	0.153	2.03	0.076	0.262	25,911	0.297	4		
	T11	WN	139,191	15	43.6	1151.6	0.038	0.439	5	0.324	0.512	2.49	0.220	0.145	20,244	0.709		121,434	0.236
1981/82 (II)	SM1	ES	29,633	18	169.4	1162.9	0.146	0.174	1	0.731	0.109	2.11	0.071	0.210	6,218	0.217			
	SM1	W1N	135,504	10	19.0	1064.9	0.018	0.684	2	0.279	0.434	2.18	0.095	0.070	9,446	0.816			
	SM1	W2S	52,096	10	76.0	920.6	0.083	0.317	3	0.399	0.303	2.14	0.127	0.221	11,512	0.456	5		
	SM2	EN	145,063	17	54.8	1748.8	0.031	0.331	2	0.279	0.434	2.18	0.095	0.122	17,755	0.554			
	SM2	W1S	35,725	9	30.9	872.2	0.035	0.318	4	0.359	0.571	3.56	0.146	0.176	6,282	0.670			
	SM2	W2S	52,096	12	94.7	812.4	0.117	0.189	5	0.501	0.276	1.86	0.075	0.216	11,257	0.342	5	51,093	0.311
1982/83 (I)	SM1	ES	33,050	15	114.6	928.0	0.124	0.214	1	0.396	0.280	2.57	0.071	0.400	13,235	0.360			
	SM1	WN	163,926	15	62.7	1426.1	0.044	0.217	2	0.804	0.162	1.63	0.106	0.044	7,288	0.291			
	SM2	EN	149,433	17	84.3	1054.4	0.080	0.303	3	0.862	0.137	3.37	0.100	0.156	23,349	0.348			
	SM2	WS	25,596	19	314.5	1414.8	0.222	0.176	4	0.615	0.098	1.66	0.043	0.300	7,688	0.206		51,559	0.190
1983/84 (VI)	K27	EMS	158,893	5	47.4	1094.4	0.043	0.394	1	0.423	0.229	1.33	0.101	0.068	10,827	0.467			
	K27	WN	207,721	5	49.9	875.6	0.057	0.142	2	0.489	0.191	2.11	0.127	0.123	25,536	0.270			
	SM1	EN	202,108	5	19.0	911.6	0.021	0.584	3	0.328	0.533	1.50	0.126	0.048	9,630	0.801			
	SM2	WMS	156,457	5	69.8	1309.0	0.053	0.187	4	0.309	0.236	2.22	0.140	0.191	29,939	0.332		75,932	0.200

Table 5b. Abundance estimates of Antarctic minke whales obtained from **CPII** surveys in **closing mode**.

Year	Vessel	Stratum	A	N_L	n_s	L	n_s/L	CV	Pool	w_s	CV	$E[s_{sc}]$	CV	D_w	P	CV	Ave	Total	CV
1985/86 (V)	K27	EN	279,611	8	38.0	865.3	0.044	0.413	1	0.362	0.260	2.58	0.191	0.157	43,872	0.524			
	K27	WS	104,814	14	44.6	767.6	0.058	0.248	2	0.625	0.140	3.55	0.216	0.165	17,267	0.358			
	SM1	EM	165,912	10	96.3	735.0	0.131	0.255	3	0.605	0.152	2.31	0.085	0.250	41,407	0.309			
	SM1	WM	166,349	4	27.5	354.0	0.078	0.498	4	0.458	0.355	1.91	0.196	0.162	27,007	0.642			
	SM2	ES	107,717	11	137.5	763.4	0.180	0.189	5	0.479	0.150	3.07	0.107	0.577	62,138	0.264			
	SM2	WN	139,065	5	19.0	566.7	0.034	0.516	6	0.304	0.297	1.88	0.198	0.104	14,416	0.628		206,107	0.180
1986/87 (II)	K27	ES1	23,142	3	7.0	179.0	0.039	0.548	1	1.043	0.148	10.11	0.681	0.190	4,390	0.886			
	K27	WS1	10,270	2	11.0	81.8	0.134	0.275	2	0.285	0.357	3.11	0.343	0.734	7,539	0.567			
	K27	WS2	21,143	2	3.0	111.0	0.027	0.121	2	0.285	0.357	3.11	0.343	0.148	3,120	0.510	6		
	K27	WS3	79,605	8	41.0	544.4	0.075	0.510	3	0.359	0.189	2.09	0.135	0.220	17,503	0.560	7		
	K27	EN	124,057	4	62.2	538.2	0.116	0.340	4	0.479	0.220	2.71	0.135	0.328	40,646	0.427			
	SM1	EBAY	15,242	3	13.0	106.4	0.122	0.381	1	1.043	0.148	10.11	0.681	0.592	9,026	0.794			
	SM1	ES2	44,975	13	42.6	565.8	0.075	0.301	5	0.524	0.403	2.66	0.182	0.192	8,617	0.535			
	SM1	WBAY	11,505	2	18.3	92.2	0.199	0.755	6	0.375	0.581	2.05	0.263	0.542	6,230	0.988			
	SM1	WN	95,361	4	3.0	315.6	0.010	0.444	4	0.479	0.220	2.71	0.135	0.027	2,569	0.513			
	SM2	EM	69,908	3	34.5	474.4	0.073	0.308	7	0.673	0.186	2.81	0.150	0.152	10,617	0.390			
	SM2	WS2	21,143	1	1.0	82.8	0.012	1.000	2	0.285	0.357	3.11	0.343	0.066	1,394	1.116	6		
	SM2	WS3	79,605	5	21.0	239.4	0.088	0.415	3	0.359	0.189	2.09	0.135	0.256	20,386	0.475	7	110,401	0.220
1987/88 (III)	SM1	ES	87,677	7	8.0	454.9	0.018	1.038	1	0.219	0.946	4.77	0.392	0.191	16,750	1.458			
	SM1	WN	148,821	6	10.8	450.4	0.024	0.939	1	0.219	0.946	4.77	0.392	0.259	38,588	1.389			
	SM2	EN	168,881	7	3.0	540.7	0.006	0.416	1	0.219	0.946	4.77	0.392	0.060	10,180	1.106			
	SM2	WS	74,351	12	59.6	623.5	0.096	0.429	2	0.375	0.335	3.29	0.145	0.419	31,173	0.563		96,690	0.830
1988/89 (IV)	SM1	BS	6,520	1	14.0	87.4	0.160	0.267	1	0.318	0.319	2.96	0.193	0.747	4,870	0.459			
	SM1	EN	181,166	6	7.0	498.8	0.014	0.333	2	0.235	0.537	4.00	0.258	0.119	21,578	0.683			
	SM1	WS	58,693	5	22.9	237.8	0.096	0.323	3	0.962	0.146	2.66	0.126	0.133	7,801	0.377			
	SM2	BN	17,486	6	7.0	231.0	0.030	0.719	1	0.318	0.319	2.96	0.193	0.141	2,471	0.810			
	SM2	ES	52,441	5	26.9	310.3	0.087	0.339	4	0.661	0.391	3.82	0.244	0.250	13,105	0.572			
	SM2	WN	156,617	6	13.0	701.9	0.019	0.761	2	0.235	0.537	4.00	0.258	0.157	24,618	0.967		74,444	0.473
1989/90 (I)	SM1	ESB	62,594	11	23.7	587.9	0.040	0.324	1	0.450	0.419	1.79	0.144	0.080	5,026	0.549			
	SM1	WN	168,761	7	26.6	560.4	0.047	0.292	2	0.510	0.264	2.25	0.249	0.104	17,621	0.465			
	SM2	EN	153,029	7	36.4	679.7	0.054	0.263	3	0.221	0.570	1.78	0.112	0.215	32,916	0.638			
	SM2	WS	45,128	15	64.0	602.2	0.106	0.201	4	0.573	0.132	2.67	0.094	0.248	11,195	0.258		66,758	0.343
1990/91 (VI)	SM1	EN	191,954	3	6.6	193.0	0.034	0.456	1	0.463	0.614	1.56	0.202	0.057	11,025	0.791			
	SM1	WS	45,414	5	5.9	304.1	0.019	0.433	1	0.463	0.614	1.56	0.202	0.032	1,474	0.778			
	SM2	ES	108,268	5	40.0	476.6	0.084	0.281	2	0.519	0.203	3.44	0.148	0.278	30,151	0.377			
	SM2	WN	211,788	5	5.0	479.7	0.010	0.232	1	0.463	0.614	1.56	0.202	0.017	3,706	0.687		46,356	0.351

Table 5c. Abundance estimates of Antarctic minke whales obtained from **CPIII** surveys in **closing mode**.

Year	Vessel	Stratum	A	N_L	n_s	L	n_s/L	CV	Pool	w_s	CV	$E[s_{sc}]$	CV	D_w	P	CV	Ave	Total	CV
1991/92 (V)	SM1	EN	165,429	9	76.2	434.0	0.176	0.210	1	0.499	0.208	2.53	0.096	0.445	73,638	0.311			
	SM1	WS	58,643	10	12.0	278.1	0.043	0.346	2	0.448	0.362	1.44	0.089	0.069	4,068	0.509			
	SM2	ES	82,039	11	48.6	645.7	0.075	0.303	2	0.448	0.362	1.44	0.089	0.121	9,925	0.481			
	SM2	WN	137,734	5	3.0	345.0	0.009	0.348	1	0.499	0.208	2.53	0.096	0.022	3,038	0.417		90,669	0.267
1992/93 (III*)	SM1	ES	23,207	10	7.7	380.2	0.020	0.437	1	0.596	0.187	1.57	0.079	0.027	616	0.482			
	SM1	WN	210,035	8	9.0	648.9	0.014	0.235	2	0.163	0.500	1.49	0.178	0.063	13,337	0.581	8		
	SM1	WS	61,527	1	2.0	67.1	0.030	0.707	1	0.596	0.187	1.57	0.079	0.039	2,414	0.736	9		
	SM2	EN	150,547	4	6.0	498.2	0.012	0.391	2	0.163	0.500	1.49	0.178	0.055	8,301	0.673			
	SM2	WS	61,527	15	79.0	812.3	0.097	0.317	1	0.596	0.187	1.57	0.079	0.128	7,882	0.377	9		
	SM2	WN	210,035	1	0.0	134.2	0.000	0.000	2	0.163	0.500	1.49	0.178	0.000	0	–	8	27,433	0.419
1993/94 (I*)	SM1	WS	50,596	11	25.6	501.7	0.051	0.276	1	0.533	0.339	1.67	0.120	0.080	4,046	0.453			
	SM1	EN	293,196	11	4.0	819.4	0.005	0.981	2	0.431	0.139	1.57	0.151	0.009	2,614	1.002			
	SM2	WN	251,735	8	17.0	583.8	0.029	0.313	2	0.431	0.139	1.57	0.151	0.053	13,388	0.375			
	SM2	ES	72,249	10	33.8	457.2	0.074	0.241	1	0.533	0.339	1.67	0.120	0.116	8,364	0.433		28,412	0.273
1994/95 (III*+IV*)	SM1	WS	51,938	12	15.6	414.3	0.038	0.336	1	0.362	0.553	2.23	0.176	0.116	6,024	0.670			
	SM1	EN	146,681	7	5.0	523.8	0.010	0.396	1	0.362	0.553	2.23	0.176	0.029	4,319	0.702			
	SM2	WN	148,803	7	3.0	463.7	0.006	0.850	1	0.362	0.553	2.23	0.176	0.020	2,969	1.029			
	SM2	ES	60,046	9	19.6	439.7	0.045	0.541	2	0.278	0.522	1.84	0.178	0.148	8,866	0.772			
	SM2	PRYD	21,096	4	18.0	210.7	0.085	0.255	3	0.772	0.157	1.54	0.144	0.085	1,796	0.332		23,975	0.457
1995/96 (VI*)	SM1	WS	34,051	10	25.8	403.3	0.064	0.299	1	0.676	0.151	1.75	0.085	0.083	2,821	0.345			
	SM1	EN	242,073	10	27.5	490.8	0.056	0.369	2	0.648	0.328	2.42	0.127	0.105	25,307	0.510			
	SM2	WN	97,945	4	6.0	246.6	0.024	0.775	2	0.648	0.328	2.42	0.127	0.045	4,451	0.851			
	SM2	ES	72,349	9	31.7	506.7	0.063	0.290	1	0.676	0.151	1.75	0.085	0.081	5,873	0.338		38,452	0.381
1996/97 (II*)	SM1	ES	52,534	20	26.4	563.6	0.047	0.383	1	0.778	0.325	1.86	0.108	0.056	2,948	0.514			
	SM1	WN	113,687	5	8.0	262.3	0.030	0.331	2	0.353	0.350	1.85	0.117	0.080	9,073	0.496			
	SM2	EN	241,928	15	14.0	588.2	0.024	0.541	2	0.353	0.350	1.85	0.117	0.062	15,069	0.655			
	SM2	WS	23,028	7	6.0	154.5	0.039	0.844	1	0.778	0.325	1.86	0.108	0.046	1,070	0.911		28,160	0.448
1997/98 (II*)	SM1	WS	32,620	7	2.0	187.0	0.011	0.751	1	0.904	0.156	2.61	0.113	0.015	503	0.775			
	SM1	EN1	84,726	6	9.0	236.0	0.038	0.600	2	0.581	0.396	1.12	0.102	0.037	3,111	0.726			
	SM1	ES2	10,451	4	28.9	83.5	0.346	0.235	1	0.904	0.156	2.61	0.113	0.499	5,215	0.303			
	SM1	EN2	80,013	2	9.0	114.3	0.079	0.619	2	0.581	0.396	1.12	0.102	0.076	6,066	0.742	10		
	SM2	WN	52,135	4	1.0	240.1	0.004	1.050	2	0.581	0.396	1.12	0.102	0.004	209	1.126			
	SM2	ES1	47,036	8	23.9	356.3	0.067	0.697	1	0.904	0.156	2.61	0.113	0.097	4,542	0.723			
	SM2	EN2	80,013	2	9.0	160.0	0.056	0.561	2	0.581	0.396	1.12	0.102	0.054	4,328	0.694	10	18,633	0.319
1998/99 (IV*)	SM1	WS	42,605	12	3.8	377.6	0.010	0.620	1	0.791	0.200	1.09	0.064	0.007	296	0.654			
	SM1	EN	169,387	11	6.0	557.4	0.011	0.282	1	0.791	0.200	1.09	0.064	0.007	1,255	0.352			
	SM2	WN	105,396	9	5.0	259.4	0.019	1.213	1	0.791	0.200	1.09	0.064	0.013	1,399	1.231			
	SM2	ES	70,193	26	19.6	608.1	0.032	0.343	1	0.791	0.200	1.09	0.064	0.022	1,555	0.403		4,505	0.456

Table 5c. Continued.

Year	Vessel	Stratum	A	N_L	n_s	L	n_s/L	CV	Pool	w_s	CV	E[s_{sc}]	CV	D_w	P	CV	Ave	Total	CV
1999/00 (I*)	SM1	WS	20,506	8	8.7	203.9	0.043	0.891	1	0.693	0.532	1.77	0.250	0.054	1,113	1.067			
	SM1	EN	57,309	6	4.5	176.6	0.026	0.524	1	0.693	0.532	1.77	0.250	0.033	1,874	0.788			
	SM2	WN	110,906	5	2.0	314.5	0.006	0.650	1	0.693	0.532	1.77	0.250	0.008	900	0.877			
	SM2	ES	23,632	4	4.7	118.2	0.040	0.574	1	0.693	0.532	1.77	0.250	0.051	1,211	0.822		5,097	0.672
2000/01 (VI*+I*)	SM1	WN	252,078	6	0.0	252.0	0.000	0.000	1	0.508	0.276	4.04	0.160	0.000	0	–	11		
	SM1	WS	43,916	8	29.2	197.8	0.148	0.138	2	0.810	0.251	2.29	0.109	0.209	9,192	0.306	12		
	SM2	WN	252,078	14	29.7	513.1	0.058	0.465	1	0.508	0.276	4.04	0.160	0.230	58,047	0.564	11		
	SM2	WS	43,916	9	26.5	142.9	0.186	0.273	2	0.810	0.251	2.29	0.109	0.263	11,563	0.386	12		
	SM1	EN	127,789	9	1.0	359.8	0.003	0.753	1	0.508	0.276	4.04	0.160	0.011	1,413	0.818			
	SM2	EN	127,789	0	0.0	0.0	–	–	–	–	–	–	–	–	–	–			
	SM2	ES	29,080	11	12.0	238.9	0.050	0.335	1	0.508	0.276	4.04	0.160	0.200	5,812	0.463		56,341	0.420
2001/02 (V*)	SM1	WS	34,886	10	17.0	248.8	0.068	0.497	1	1.044	0.291	1.33	0.142	0.043	1,517	0.594			
	SM1	ES	26,099	5	13.9	140.0	0.099	0.745	2	0.647	0.446	1.29	0.100	0.099	2,578	0.874	14		
	SM2	WN	46,333	4	4.0	254.4	0.016	0.613	2	0.647	0.446	1.29	0.100	0.016	725	0.764			
	SM2	EN	83,082	4	2.0	191.4	0.010	0.992	2	0.647	0.446	1.29	0.100	0.010	863	1.092			
	SM2	ES	26,099	1	1.0	52.2	0.019	1.000	2	0.647	0.446	1.29	0.100	0.019	498	1.100	14	5,118	0.495
2002/03 (V*)	SM1	ES	126,870	13	20.8	482.1	0.043	0.344	1	0.328	0.736	1.54	0.157	0.101	12,818	0.827			
	SM1	EN	135,038	4	3.0	108.3	0.028	0.468	2	0.222	0.796	1.81	0.146	0.113	15,204	0.935	15		
	SM1	W2N	101,237	5	8.0	205.3	0.039	0.506	2	0.222	0.796	1.81	0.146	0.158	15,961	0.954	16		
	SM1	W1S	22,128	5	11.0	123.5	0.089	0.209	3	0.729	0.200	3.77	0.146	0.230	5,094	0.324			
	SM2	EN	135,038	10	6.0	396.0	0.015	0.236	2	0.222	0.796	1.81	0.146	0.062	8,314	0.843	15		
	SM2	W2S	21,327	13	21.0	268.9	0.078	0.406	3	0.729	0.200	3.77	0.146	0.202	4,304	0.475			
	SM2	W1N	75,395	6	19.7	221.4	0.089	0.289	4	0.825	0.256	1.65	0.146	0.089	6,724	0.413			
	SM2	W2N	101,237	1	10.0	13.2	0.757	0.316	2	0.222	0.796	1.81	0.146	3.076	311,377	0.869	16	72,553	0.529
2003/04 (V*)	SM2	N1	123,227	6	5.0	321.3	0.016	0.293	1	0.480	0.303	3.38	0.102	0.055	6,749	0.434			
	SM1	N2	95,445	9	4.0	298.5	0.013	0.581	1	0.480	0.303	3.38	0.102	0.047	4,501	0.663			
	SM1	N3	14,598	1	2.7	40.5	0.066	0.611	1	0.480	0.303	3.38	0.102	0.233	3,405	0.689			
	SM1	ROSS	56,444	10	17.9	255.4	0.070	0.166	2	0.352	0.422	1.34	0.422	0.133	7,526	0.459	17		
	SM2	ROSS	56,444	8	39.9	267.1	0.149	0.326	2	0.352	0.422	1.34	0.303	0.284	16,016	0.538	17		
	SM1	MID	131,782	10	15.0	254.5	0.059	0.201	1	0.480	0.303	3.38	0.102	0.207	27,341	0.378	18		
	SM2	MID	131,782	11	54.6	424.5	0.129	0.237	1	0.480	0.303	3.38	0.102	0.453	59,676	0.398	18	74,077	0.310

Table 5d. Abundance estimates of Antarctic minke whales obtained from **CPII** surveys in **IO mode**.

Year	Vessel	Stratum	A	N_L	n_s	L	n_s/L	CV	Pool	w_s	CV	$E[s_{sc}]$	CV	D_w	P	CV	Ave	Total	CV
1985/86 (V)	K27	EN	279,611	8	69.3	884.4	0.078	0.325	1	0.702	0.157	2.58	0.191	0.144	40,338	0.408			
	K27	WS	104,814	13	109.4	662.0	0.165	0.147	2	0.812	0.214	3.55	0.216	0.361	37,886	0.338			
	SM1	EM	165,912	10	182.8	1091.7	0.167	0.404	3	0.720	0.099	2.31	0.085	0.268	44,509	0.425			
	SM1	WM	166,349	4	42.4	492.0	0.086	0.593	4	0.355	0.273	1.91	0.196	0.232	38,583	0.682			
	SM2	ES	107,717	8	181.3	741.1	0.245	0.280	5	0.428	0.108	3.07	0.107	0.876	94,403	0.319			
	SM2	WN	139,065	3	45.0	389.6	0.116	0.382	6	0.322	0.218	1.88	0.198	0.337	46,913	0.483		302,632	0.178
1986/87 (II)	K27	ES1	23,142	5	25.0	348.6	0.072	0.526	1	1.100	0.093	10.11	0.681	0.330	7,631	0.865			
	K27	WS1	10,270	2	10.0	103.7	0.096	0.384	2	0.640	0.202	3.11	0.343	0.235	2,409	0.553			
	K27	WS2	21,143	2	4.0	128.7	0.031	1.087	2	0.640	0.202	3.11	0.343	0.076	1,598	1.157	6		
	K27	WS3	79,605	7	42.4	470.4	0.090	0.250	3	0.456	0.176	2.09	0.135	0.207	16,461	0.334	7		
	K27	EN	124,057	3	47.5	427.7	0.111	0.449	4	0.215	0.649	2.71	0.135	0.700	86,823	0.801			
	SM1	EBAY	15,242	4	35.8	125.8	0.284	0.367	1	1.100	0.093	10.11	0.681	1.307	19,929	0.779			
	SM1	ES2	44,975	16	100.7	722.0	0.139	0.246	5	0.601	0.248	2.66	0.182	0.309	13,910	0.393			
	SM1	WBAY	11,505	1	28.3	74.2	0.382	0.188	6	0.368	0.353	2.05	0.263	1.063	12,226	0.478			
	SM1	WN	95,361	2	0.0	201.0	0.000	0.000	4	0.215	0.649	2.71	0.135	0.000	0	–			
	SM2	EM	69,908	3	72.7	447.0	0.163	0.265	7	0.922	0.123	2.81	0.150	0.247	17,296	0.329			
	SM2	WS2	21,143	2	2.0	151.8	0.013	0.346	2	0.640	0.202	3.11	0.343	0.032	677	0.527	6		
	SM2	WS3	79,605	8	44.8	449.8	0.100	0.395	3	0.456	0.176	2.09	0.135	0.229	18,220	0.453	7	178,644	0.411
1987/88 (III)	SM1	ES	87,677	8	30.7	660.1	0.046	0.512	1	0.505	0.234	4.77	0.392	0.219	19,212	0.686			
	SM1	WN	148,821	7	25.6	365.1	0.070	0.356	1	0.505	0.234	4.77	0.392	0.331	49,226	0.579			
	SM2	EN	168,881	7	9.0	546.1	0.016	0.394	1	0.505	0.234	4.77	0.392	0.078	13,127	0.604			
	SM2	WS	74,351	9	143.0	617.9	0.231	0.141	2	0.574	0.130	3.29	0.145	0.664	49,339	0.241		130,903	0.338
1988/89 (IV)	SM1	BS	6,520	3	48.5	144.5	0.335	0.763	1	0.832	0.185	2.96	0.193	0.597	3,891	0.809			
	SM1	EN	181,166	6	17.0	617.5	0.028	0.247	2	0.279	0.638	4.00	0.258	0.197	35,682	0.731			
	SM1	WS	58,693	5	23.0	245.7	0.094	0.320	3	0.552	0.538	2.66	0.126	0.225	13,194	0.638			
	SM2	BN	17,486	9	23.8	396.8	0.060	0.252	1	0.832	0.185	2.96	0.193	0.107	1,865	0.367			
	SM2	ES	52,441	4	43.6	244.0	0.179	0.262	4	0.983	0.165	3.82	0.244	0.347	18,213	0.394			
	SM2	WN	156,617	6	1.0	730.0	0.001	1.115	2	0.279	0.638	4.00	0.258	0.010	1,535	1.310		74,380	0.397
1989/90 (I)	SM1	ESB	62,594	13	66.8	798.9	0.084	0.446	1	0.863	0.133	1.79	0.144	0.087	5,432	0.487			
	SM1	WN	168,761	6	30.8	606.7	0.051	0.325	2	0.916	0.349	2.25	0.249	0.062	10,522	0.537			
	SM2	EN	153,029	7	45.0	750.2	0.060	0.257	3	0.419	0.175	1.78	0.112	0.127	19,454	0.330			
	SM2	WS	45,128	15	184.3	830.9	0.222	0.229	4	0.519	0.152	2.67	0.094	0.571	25,783	0.291		61,191	0.191
1990/91 (VI)	SM1	EN	191,954	4	22.0	473.6	0.046	0.635	1	0.516	0.208	1.56	0.202	0.070	13,441	0.698			
	SM1	WS	45,414	9	36.9	645.9	0.057	0.226	1	0.516	0.208	1.56	0.202	0.086	3,906	0.367			
	SM2	ES	108,268	4	19.0	476.3	0.040	0.518	2	0.570	0.252	3.44	0.148	0.120	13,023	0.594			
	SM2	WN	211,788	4	12.0	563.7	0.021	0.389	1	0.516	0.208	1.56	0.202	0.032	6,796	0.484		37,166	0.370

Table 5e. Abundance estimates of Antarctic minke whales obtained from **CPIII** surveys in **IO mode**.

Year	Vessel	Stratum	A	N_L	n_s	L	n_s/L	CV	Pool	w_s	CV	$E[s_{sc}]$	CV	D_w	P	CV	Ave	Total	CV
1991/92 (V)	SM1	EN	165,429	8	113.9	574.8	0.198	0.230	1	0.649	0.154	2.53	0.096	0.386	63,876	0.293			
	SM1	WS	58,643	5	134.9	470.0	0.287	0.453	2	0.805	0.096	1.44	0.089	0.257	15,064	0.472			
	SM2	ES	82,039	10	77.0	687.5	0.112	0.417	2	0.805	0.096	1.44	0.089	0.100	8,221	0.437			
	SM2	WN	137,734	4	10.0	310.3	0.032	0.691	1	0.649	0.154	2.53	0.096	0.063	8,650	0.714		95,812	0.231
1992/93 (III*)	SM1	ES	23,207	11	17.0	408.8	0.042	0.340	1	0.545	0.153	1.57	0.079	0.060	1,392	0.381			
	SM1	WN	210,035	7	32.0	755.6	0.042	0.444	2	1.097	0.106	1.49	0.178	0.029	6,053	0.490	8		
	SM1	WS	61,527	2	3.0	75.8	0.040	0.050	1	0.545	0.153	1.57	0.079	0.057	3,511	0.179	9		
	SM2	EN	150,547	5	12.0	603.0	0.020	0.483	2	1.097	0.106	1.49	0.178	0.014	2,040	0.525			
	SM2	WS	61,527	14	149.0	905.4	0.165	0.215	1	0.545	0.153	1.57	0.079	0.237	14,608	0.275	9		
	SM2	WN	210,035	0	0.0	0.0	–	–	–	–	–	–	–	–	0	–	8	23,235	0.221
1993/94 (I*)	SM1	WS	50,596	12	52.0	566.6	0.092	0.216	1	0.470	0.117	1.67	0.120	0.163	8,235	0.273			
	SM1	EN	293,196	11	11.0	762.5	0.014	0.642	2	0.322	0.313	1.57	0.151	0.035	10,348	0.730			
	SM2	WN	251,735	8	8.0	550.2	0.015	0.267	2	0.322	0.313	1.57	0.151	0.036	8,953	0.438			
	SM2	ES	72,249	10	72.2	598.1	0.121	0.363	1	0.470	0.117	1.67	0.120	0.214	15,480	0.400		43,016	0.280
1994/95 (III*+IV*)	SM1	WS	51,938	11	43.6	505.3	0.086	0.440	1	0.928	0.105	2.23	0.176	0.104	5,388	0.486			
	SM1	EN	146,681	8	20.0	630.7	0.032	0.514	1	0.928	0.105	2.23	0.176	0.038	5,594	0.553			
	SM2	WN	148,803	7	15.3	457.9	0.033	0.416	1	0.928	0.105	2.23	0.176	0.040	5,977	0.464			
	SM2	ES	60,046	8	36.9	459.5	0.080	0.432	2	0.521	0.227	1.84	0.178	0.141	8,494	0.519			
	SM2	PRYD	21,096	4	40.0	203.5	0.197	0.296	3	0.754	0.082	1.54	0.144	0.201	4,232	0.339		29,685	0.247
1995/96 (VI*)	SM1	WS	34,051	9	10.0	335.6	0.030	0.574	1	0.671	0.164	1.75	0.085	0.039	1,325	0.603			
	SM1	EN	242,073	11	21.0	554.6	0.038	0.374	2	0.504	0.332	2.42	0.127	0.091	21,964	0.516			
	SM2	WN	97,945	5	10.8	281.8	0.038	0.251	2	0.504	0.332	2.42	0.127	0.092	9,001	0.435			
	SM2	ES	72,349	10	40.6	561.8	0.072	0.258	1	0.671	0.164	1.75	0.085	0.094	6,820	0.318		39,109	0.361
1996/97 (II*)	SM1	ES	52,534	18	30.7	665.6	0.046	0.428	1	0.589	0.159	1.86	0.108	0.073	3,830	0.469			
	SM1	WN	113,687	5	8.0	201.6	0.040	0.626	2	0.247	0.864	1.85	0.117	0.148	16,875	1.074			
	SM2	EN	241,928	17	14.0	672.2	0.021	0.221	2	0.247	0.864	1.85	0.117	0.078	18,845	0.900			
	SM2	WS	23,028	8	25.0	230.0	0.109	0.229	1	0.589	0.159	1.86	0.108	0.172	3,957	0.299		43,507	0.764
1997/98 (II*)	SM1	WS	32,620	10	2.0	303.2	0.007	0.916	1	0.714	0.100	2.61	0.113	0.012	393	0.929			
	SM1	EN1	84,726	6	6.8	345.1	0.020	0.420	2	0.652	0.354	1.12	0.102	0.017	1,438	0.559			
	SM1	ES2	10,451	5	11.6	142.8	0.081	1.309	1	0.714	0.100	2.61	0.113	0.148	1,550	1.318			
	SM1	EN2	80,013	2	2.0	87.8	0.023	0.954	2	0.652	0.354	1.12	0.102	0.020	1,565	1.022	10		
	SM2	WN	52,135	4	6.0	253.3	0.024	0.434	2	0.652	0.354	1.12	0.102	0.020	1,061	0.569			
	SM2	ES1	47,036	8	37.0	385.1	0.096	0.659	1	0.714	0.100	2.61	0.113	0.175	8,247	0.676			
	SM2	EN2	80,013	2	5.0	170.8	0.029	0.598	2	0.652	0.354	1.12	0.102	0.025	2,003	0.703	10	14,542	0.436
1998/99 (IV*)	SM1	WS	42,605	14	14.7	472.3	0.031	0.387	1	0.715	0.226	1.09	0.064	0.024	1,013	0.453			
	SM1	EN	169,387	14	18.5	578.7	0.032	0.231	1	0.715	0.226	1.09	0.064	0.024	4,120	0.330			
	SM2	WN	105,396	9	17.9	377.8	0.047	1.085	1	0.715	0.226	1.09	0.064	0.036	3,807	1.110			
	SM2	ES	70,193	24	22.6	633.4	0.036	0.200	1	0.715	0.226	1.09	0.064	0.027	1,906	0.309		10,847	0.459

Table 5e. Continued.

Year	Vessel	Stratum	A	N_L	n_s	L	n_s/L	CV	Pool	w_s	CV	E[s_{sc}]	CV	D_w	P	CV	Ave	Total	CV
	SM1	WS	20,506	5	3.0	243.0	0.012	0.338	1	0.544	0.238	1.77	0.250	0.020	412	0.482			
1999/00	SM1	EN	57,309	5	7.0	241.1	0.029	0.287	1	0.544	0.238	1.77	0.250	0.047	2,705	0.449			
(I*)	SM2	WN	110,906	6	2.0	349.9	0.006	0.626	1	0.544	0.238	1.77	0.250	0.009	1,031	0.715			
	SM2	ES	23,632	7	8.4	179.8	0.047	0.228	1	0.544	0.238	1.77	0.250	0.076	1,800	0.413		5,947	0.391
	SM1	WN	252,078	6	6.0	262.0	0.023	0.365	1	0.904	0.151	4.04	0.160	0.051	12,898	0.426	11		
	SM1	WS	43,916	8	26.8	248.7	0.108	0.321	2	0.597	0.379	2.29	0.109	0.207	9,091	0.508	12		
2000/01	SM2	WN	252,078	7	5.0	197.2	0.025	0.559	1	0.904	0.151	4.04	0.160	0.057	14,280	0.601	11		
(VI*+I*)	SM2	WS	43,916	7	17.0	168.7	0.101	0.335	2	0.597	0.379	2.29	0.109	0.194	8,513	0.517	12		
	SM1	EN	127,789	10	1.0	341.0	0.003	0.611	1	0.904	0.151	4.04	0.160	0.007	837	0.649	13		
	SM2	EN	127,789	2	1.0	37.3	0.027	0.068	1	0.904	0.151	4.04	0.160	0.060	7,652	0.230	13		
	SM2	ES	29,080	9	16.0	303.8	0.053	0.336	1	0.904	0.151	4.04	0.160	0.118	3,422	0.401		27,280	0.221
	SM1	WS	34,886	11	22.1	301.6	0.073	0.531	1	0.526	0.555	1.33	0.142	0.093	3,237	0.780			
2001/02	SM1	ES	26,099	6	14.5	152.9	0.095	0.358	2	0.860	0.163	1.29	0.100	0.071	1,852	0.406	14		
(V*)	SM2	WN	46,333	3	4.0	184.1	0.022	0.769	2	0.860	0.163	1.29	0.100	0.016	752	0.793			
	SM2	EN	83,082	4	2.0	295.0	0.007	0.564	2	0.860	0.163	1.29	0.100	0.005	421	0.595			
	SM2	ES	26,099	2	5.0	79.0	0.063	0.681	2	0.860	0.163	1.29	0.100	0.047	1,235	0.707	14	6,053	0.448
	SM1	ES	126,870	11	33.5	536.0	0.062	0.560	1	0.863	0.302	1.54	0.157	0.056	7,066	0.655			
	SM1	EN	135,038	2	1.0	75.7	0.013	0.038	2	0.424	0.244	1.81	0.146	0.028	3,799	0.287	15		
2002/03	SM1	W2N	101,237	6	4.0	253.8	0.016	0.170	2	0.424	0.244	1.81	0.146	0.034	3,397	0.332	16		
(V*)	SM1	W1S	22,128	7	23.9	228.5	0.105	0.321	3	0.661	0.214	3.77	0.146	0.298	6,594	0.413			
	SM2	EN	135,038	13	10.0	465.6	0.021	0.246	2	0.424	0.244	1.81	0.146	0.046	6,175	0.376	15		
	SM2	W2S	21,327	14	17.0	257.1	0.066	0.210	3	0.661	0.214	3.77	0.146	0.189	4,020	0.334			
	SM2	W1N	75,395	7	18.0	244.6	0.074	0.164	4	0.556	0.130	1.65	0.146	0.109	8,252	0.255			
	SM2	W2N	101,237	3	5.0	30.6	0.164	0.222	2	0.424	0.244	1.81	0.146	0.348	35,264	0.361	16	38,595	0.191
	SM2	N1	123,227	7	3.0	167.7	0.018	0.513	1	0.854	0.133	3.38	0.102	0.035	4,365	0.540			
	SM1	N2	95,445	9	22.0	288.7	0.076	0.420	1	0.854	0.133	3.38	0.102	0.151	14,405	0.452			
2003/04	SM1	N3	14,598	3	32.9	112.6	0.292	0.061	1	0.854	0.133	3.38	0.102	0.579	8,450	0.179			
(V*)	SM1	ROSS	56,444	13	58.9	289.2	0.204	0.145	2	0.635	0.203	1.34	0.070	0.215	12,110	0.259	17		
	SM2	ROSS	56,444	7	72.2	289.5	0.249	0.217	2	0.635	0.203	1.34	0.070	0.262	14,812	0.306	17		
	SM1	MID	131,782	8	102.5	452.8	0.226	0.386	1	0.854	0.133	3.38	0.102	0.448	59,099	0.421	18		
	SM2	MID	131,782	12	111.5	457.1	0.244	0.261	1	0.854	0.133	3.38	0.102	0.483	63,632	0.310	18	102,057	0.213

Table 6. Estimates of the ratio, R, between closing mode and IO mode school density for all strata, for CPII strata and for CPIII strata, together with individual estimates of school density, D_s, and these ratios for each stratum or superstratum.

Year	Stratum	D_s	CV	D_s	CV	R	CV
1985/86	1	0.056	0.361	0.061	0.488	1.088	0.607
1985/86	2	0.102	0.260	0.046	0.285	0.456	0.386
1985/86	3	0.116	0.416	0.108	0.297	0.930	0.512
1985/86	4	0.121	0.653	0.085	0.611	0.700	0.894
1985/86	5	0.286	0.301	0.188	0.241	0.658	0.385
1985/86	6	0.179	0.440	0.055	0.596	0.307	0.741
1986/87	1	0.071	0.317	0.035	0.346	0.487	0.469
1986/87	2	0.036	0.404	0.101	0.419	2.828	0.582
1986/87	3	0.104	0.295	0.110	0.411	1.061	0.506
1986/87	4	0.146	0.789	0.073	0.389	0.498	0.880
1986/87	5	0.116	0.349	0.072	0.503	0.620	0.612
1986/87	6	0.519	0.400	0.265	0.953	0.510	1.033
1986/87	7	0.088	0.292	0.054	0.360	0.614	0.464
1987/88	1	0.042	0.346	0.034	1.129	0.803	1.181
1987/88	2	0.202	0.192	0.127	0.544	0.632	0.577
1988/89	1	0.081	0.554	0.103	0.438	1.275	0.707
1988/89	2	0.028	0.681	0.034	0.691	1.241	0.970
1988/89	3	0.085	0.625	0.050	0.355	0.591	0.719
1988/89	4	0.091	0.310	0.065	0.517	0.720	0.603
1989/90	1	0.048	0.465	0.045	0.529	0.925	0.705
1989/90	2	0.028	0.476	0.046	0.394	1.675	0.618
1989/90	3	0.072	0.311	0.121	0.628	1.692	0.701
1989/90	4	0.214	0.275	0.093	0.240	0.434	0.365
1990/91	1	0.035	0.426	0.023	0.691	0.671	0.812
1990/91	2	0.035	0.576	0.081	0.347	2.315	0.672
1991/92	1	0.095	0.267	0.100	0.290	1.057	0.394
1991/92	2	0.115	0.342	0.069	0.433	0.601	0.552
1992/93	1	0.114	0.578	0.061	0.662	0.534	0.879
1992/93	2	0.015	1.153	0.040	0.265	2.675	1.183
1993/94	1	0.116	0.275	0.061	0.386	0.523	0.474
1993/94	2	0.022	0.481	0.019	0.337	0.829	0.588
1994/95	1	0.022	0.284	0.017	0.617	0.785	0.679
1994/95	2	0.077	0.487	0.080	0.752	1.044	0.896
1994/95	3	0.130	0.307	0.055	0.299	0.424	0.429
1995/96	1	0.044	0.287	0.047	0.265	1.067	0.391
1995/96	2	0.038	0.431	0.036	0.469	0.961	0.637
1996/97	1	0.055	0.288	0.029	0.485	0.516	0.564
1996/97	2	0.054	0.921	0.037	0.502	0.676	1.049
1997/98	1	0.043	0.914	0.044	0.963	1.007	1.328
1997/98	2	0.018	0.450	0.035	0.520	1.924	0.688
1998/99	1	0.026	0.454	0.011	0.451	0.415	0.641
1999/00	1	0.016	0.301	0.014	0.624	0.857	0.693
2000/01	1	0.011	0.288	0.028	0.482	2.505	0.562
2000/01	2	0.088	0.446	0.101	0.292	1.150	0.533
2001/02	1	0.070	0.767	0.033	0.576	0.469	0.960
2001/02	2	0.014	0.332	0.018	0.650	1.279	0.730
2002/03	1	0.036	0.636	0.066	0.812	1.814	1.032
2002/03	2	0.030	0.276	0.102	0.828	3.442	0.873
2002/03	3	0.065	0.303	0.057	0.295	0.885	0.423
2002/03	4	0.066	0.209	0.054	0.386	0.815	0.439
2003/04	1	0.072	0.220	0.050	0.342	0.702	0.406
2003/04	2	0.178	0.245	0.157	0.481	0.881	0.540
R for all strata combined						0.815	0.075
R for CPII strata						0.761	0.109
R for CPIII strata						0.872	0.104

Table 7. Estimates of the ratio, R, between closing mode and IO mode school density for all strata, when **like minke** sightings are included, together with individual estimates of school density, D_s, and these ratios for each stratum or superstratum.

Year	Stratum	D_s	CV	D_s	CV	R	CV
1985/86	1	0.057	0.353	0.064	0.467	1.128	0.586
1985/86	2	0.102	0.260	0.047	0.278	0.466	0.381
1985/86	3	0.134	0.402	0.120	0.277	0.899	0.488
1985/86	4	0.151	0.588	0.085	0.611	0.562	0.849
1985/86	5	0.308	0.305	0.195	0.236	0.633	0.386
1985/86	6	0.253	0.447	0.067	0.580	0.264	0.733
1986/87	1	0.076	0.310	0.036	0.327	0.475	0.450
1986/87	2	0.049	0.470	0.101	0.419	2.051	0.629
1986/87	3	0.112	0.290	0.117	0.401	1.052	0.495
1986/87	4	0.171	0.747	0.077	0.377	0.451	0.837
1986/87	5	0.127	0.344	0.075	0.497	0.588	0.605
1986/87	6	0.610	0.393	0.305	0.956	0.500	1.033
1986/87	7	0.089	0.292	0.054	0.360	0.609	0.464
1987/88	1	0.055	0.364	0.038	1.105	0.678	1.163
1987/88	2	0.221	0.185	0.132	0.534	0.596	0.565
1988/89	1	0.083	0.543	0.108	0.451	1.301	0.706
1988/89	2	0.031	0.673	0.038	0.670	1.224	0.950
1988/89	3	0.088	0.629	0.050	0.355	0.567	0.722
1988/89	4	0.097	0.334	0.065	0.517	0.675	0.616
1989/90	1	0.054	0.457	0.052	0.524	0.966	0.695
1989/90	2	0.038	0.553	0.054	0.390	1.414	0.677
1989/90	3	0.098	0.280	0.144	0.645	1.469	0.703
1989/90	4	0.244	0.252	0.101	0.224	0.416	0.337
1990/91	1	0.043	0.377	0.028	0.671	0.658	0.770
1990/91	2	0.050	0.398	0.093	0.339	1.871	0.523
1991/92	1	0.110	0.239	0.111	0.284	1.011	0.372
1991/92	2	0.148	0.351	0.080	0.417	0.538	0.545
1992/93	1	0.126	0.574	0.070	0.651	0.558	0.868
1992/93	2	0.018	1.144	0.054	0.209	3.021	1.163
1993/94	1	0.154	0.239	0.074	0.377	0.481	0.446
1993/94	2	0.033	0.519	0.022	0.307	0.662	0.603
1994/95	1	0.027	0.245	0.019	0.620	0.728	0.667
1994/95	2	0.101	0.443	0.106	0.680	1.046	0.812
1994/95	3	0.155	0.318	0.071	0.312	0.456	0.445
1995/96	1	0.056	0.284	0.053	0.246	0.934	0.376
1995/96	2	0.055	0.389	0.040	0.459	0.730	0.601
1996/97	1	0.078	0.252	0.030	0.471	0.387	0.534
1996/97	2	0.078	0.919	0.042	0.480	0.535	1.037
1997/98	1	0.061	0.823	0.050	0.952	0.819	1.258
1997/98	2	0.020	0.429	0.038	0.505	1.885	0.663
1998/99	1	0.036	0.464	0.015	0.339	0.428	0.575
1999/00	1	0.020	0.309	0.016	0.621	0.800	0.694
2000/01	1	0.016	0.273	0.030	0.463	1.860	0.537
2000/01	2	0.096	0.437	0.110	0.298	1.143	0.529
2001/02	1	0.077	0.731	0.035	0.543	0.450	0.911
2001/02	2	0.024	0.292	0.019	0.639	0.784	0.703
2002/03	1	0.042	0.566	0.066	0.812	1.553	0.990
2002/03	2	0.043	0.265	0.107	0.832	2.480	0.873
2002/03	3	0.074	0.276	0.059	0.300	0.791	0.407
2002/03	4	0.091	0.216	0.062	0.340	0.680	0.403
2003/04	1	0.078	0.211	0.055	0.335	0.701	0.396
2003/04	2	0.187	0.243	0.160	0.477	0.857	0.536
R for all strata combined						0.750	0.073
R for CPII strata						0.717	0.106
R for CPIII strata						0.784	0.101

Table 8. Comparison of inverse-variance weighted abundance estimates with the original estimates and those of Branch and Butterworth (2001).

Reference for original	Survey	Original		Branch & Butterworth		This paper		Ratio to original	Ratio to B&B
		Total	CV	Total	CV	Total	CV		
Haw (1993a)	1978/79	97,027	0.218	113,569	0.172	120,163	0.186	1.24	1.06
Haw (1993a)	1979/80	81,587	0.242	123,714	0.235	130,813	0.244	1.60	1.06
Haw (1993a)	1980/81	177,606	0.264	161,695	0.245	159,572	0.260	0.90	0.99
Haw (1993a)	1981/82	47,617	0.254	45,580	0.221	67,140	0.330	1.41	1.47
Haw (1993a)	1982/83	73,302	0.254	63,932	0.213	67,752	0.219	0.92	1.06
Haw (1993a)	1983/84	107,959	0.287	99,786	0.276	99,779	0.228	0.92	1.00
Haw (1993a)	1985/86	294,610	0.138	299,793	0.135	287,646	0.136	0.98	0.96
Haw (1993a)	1986/87	122,156	0.190	131,177	0.180	151,472	0.212	1.24	1.15
Haw (1993a)	1987/88	88,735	0.273	138,022	0.273	130,336	0.314	1.47	0.94
Haw (1993a)	1988/89	74,692	0.257	58,170	0.228	80,912	0.310	1.08	1.39
Haw (1991)	1989/90	53,314	0.166	63,972	0.170	64,390	0.170	1.21	1.01
Haw (1993b)	1990/91	56,039	0.290	56,807	0.283	43,672	0.268	0.78	0.77
Borchers (1993)	1991/92	92,709	0.194	98,682	0.177	98,718	0.180	1.06	1.00
Borchers & Cameron (1995)	1992/93	15,587	0.168	25,363	0.220	24,264	0.198	1.56	0.96
Borchers & Burt (1996)	1993/94	26,687	0.218	37,479	0.211	36,590	0.204	1.37	0.98
Burt & Borchers (1996)	1994/95	24,905	0.208	31,620	0.198	29,151	0.218	1.17	0.92
Burt & Borchers (1997)	1995/96	38,317	0.223	37,839	0.207	41,090	0.267	1.07	1.09
Burt & Borchers (1999)	1996/97	28,143	0.241	28,158	0.236	34,156	0.397	1.21	1.21
Burt & Stahl (2000)	1997/98	14,033	0.280	15,434	0.282	17,539	0.271	1.25	1.14
Burt & Stahl (2001)	1998/99	6,540	0.400			6,249	0.348	0.96	–
Burt & Hughes (2002)	1999/00	5,910	0.339			5,921	0.339	1.00	–
Burt (2002)	2000/01	35,150	0.309			28,940	0.204	0.82	–
Burt & Hughes (2003)	2001/02	9,593	0.247			5,970	0.335	0.62	–
Burt & Hughes (2004)	2002/03	46,910	0.219			39,767	0.183	0.85	–
Burt & Hughes (2005)	2003/04	98,522	0.189			95,548	0.179	0.97	–

Table 9. Inverse-variance weighted estimates for the individual surveys, adjusted to obtain circumpolar estimates, further adjusted for comparable areas, and adjusted for comparable areas plus including like minke sightings.

Survey	Individual surveys		Survey-once		Comparable areas		Comparable + like	
	Total	CV	Total	CV	Total	CV	Total	CV
1978/79	120,163	0.186	120,163	0.186	141,465	0.188	150,194	0.201
1979/80	130,813	0.244	130,813	0.244	183,918	0.263	195,266	0.262
1980/81	159,572	0.260	159,572	0.260	269,084	0.294	286,521	0.293
1981/82	67,140	0.330	67,140	0.330	115,908	0.371	123,060	0.370
1982/83	67,752	0.219	67,752	0.219	118,605	0.239	125,923	0.238
1983/84	99,779	0.228	99,779	0.228	101,976	0.232	108,269	0.231
1985/86	287,646	0.136	287,646	0.136	278,693	0.136	295,114	0.135
1986/87	151,472	0.212	151,472	0.212	182,622	0.231	193,659	0.208
1987/88	130,336	0.314	130,336	0.314	222,304	0.341	256,571	0.367
1988/89	80,912	0.310	80,912	0.310	86,776	0.291	59,745	0.213
1989/90	64,390	0.170	64,390	0.170	104,455	0.192	117,124	0.208
1990/91	43,672	0.268	43,672	0.268	47,384	0.253	50,322	0.217
1991/92	98,718	0.180	–	–	–	–	–	–
1992/93	24,264	0.198	24,264	0.198	24,264	0.198	27,342	0.191
1993/94	36,590	0.204	24,864	0.271	24,864	0.271	30,957	0.242
1994/95	29,151	0.218	29,151	0.218	29,151	0.218	37,950	0.204
1995/96	41,090	0.267	41,090	0.267	41,090	0.267	48,654	0.223
1996/97	34,156	0.397	17,003	0.245	18,442	0.233	27,191	0.236
1997/98	17,539	0.271	17,539	0.271	17,313	0.250	18,451	0.209
1998/99	6,249	0.348	6,249	0.348	6,249	0.348	8,387	0.282
1999/00	5,921	0.339	5,921	0.339	5,921	0.339	7,904	0.351
2000/01	28,940	0.204	28,940	0.204	28,940	0.204	35,130	0.200
2001/02	5,970	0.335	5,970	0.335	5,970	0.335	7,826	0.305
2002/03	39,767	0.183	32,747	0.265	32,747	0.265	40,047	0.250
2003/04	95,548	0.179	93,164	0.180	93,164	0.180	99,246	0.172

Table 10. Estimates of circumpolar abundance for each circumpolar set of surveys, together with the same estimates adjusted for comparable areas and also adjusted for comparable areas plus including like minke sightings.

Circumpolar	Closing mode		IO mode		Pseudo-passing		Inverse-var weighted	
Year	Total	CV	Total	CV	Total	CV	Total	CV
CPI	491,012	0.092	–	–	645,219	0.143	645,219	0.143
CPII	600,755	0.170	784,916	0.110	789,428	0.202	785,932	0.094
CPIII	376,465	0.262	331,166	0.102	431,726	0.282	338,336	0.079
CPIII/CPI	0.77	0.278	–	–	0.67	0.316	0.52	0.163
CPIII/CPII	0.63	0.313	0.42	0.150	0.55	0.347	0.43	0.123

Comparable areas	Closing mode		IO mode		Pseudo-passing		Inverse-var weighted	
Year	Total	CV	Total	CV	Total	CV	Total	CV
CPI	708,457	0.111	–	–	930,955	0.155	930,955	0.155
CPII	760,665	0.225	958,497	0.161	999,559	0.250	969,811	0.109
CPIII	377,686	0.261	331,392	0.102	433,126	0.281	338,653	0.079
CPIII/CPI	0.53	0.283	–	–	0.47	0.321	0.36	0.174
CPIII/CPII	0.50	0.344	0.35	0.190	0.43	0.376	0.35	0.135

Comparable areas + like	Closing mode		IO mode		Pseudo-passing		Inverse-var weighted	
Year	Total	CV	Total	CV	Total	CV	Total	CV
CPI	709,055	0.111	–	–	989,234	0.154	989,234	0.154
CPII	745,562	0.200	1,014,523	0.149	1,040,166	0.227	1,021,999	0.117
CPIII	402,808	0.177	390,013	0.086	513,626	0.204	401,528	0.072
CPIII/CPI	0.57	0.209	–	–	0.52	0.255	0.41	0.170
CPIII/CPII	0.54	0.267	0.38	0.172	0.49	0.305	0.39	0.137

Table 11. Inverse-variance weighted estimates of abundance for individual IWC Management Areas, when corrected for comparable areas, and when additionally like minke sightings are included. Closing mode estimates are divided by R to obtained pseudo-IO estimates and then the pseudo-IO and IO mode estimates are combined using inverse-variance weighting. Note that different estimates of R are used for CPI+CPII and for CPIII, and that are recalculated when like minkes are included.

Management Areas	Area I		Area II		Area III		Area IV		Area V		Area VI	
	P	CV	P	CV	P	CV	P	CV	P	CV	P	CV
Closing CPI	51,559	0.190	51,093	0.311	99,549	0.219	91,444	0.151	121,434	0.236	75,932	0.200
Closing CPII	66,758	0.343	110,401	0.220	96,690	0.830	74,444	0.473	206,107	0.180	46,356	0.351
Closing CPIII	33,655	0.231	42,816	0.302	45,676	0.299	10,202	0.417	156,513	0.589	87,567	0.303
IO CPII	61,191	0.191	178,644	0.411	130,903	0.338	74,380	0.397	302,632	0.178	37,166	0.370
IO CPIII	37,030	0.381	30,418	0.253	49,370	0.166	14,493	0.368	138,493	0.168	61,458	0.249
Pseudo-IO CPI	67,752	0.219	67,140	0.330	130,813	0.244	120,163	0.186	159,572	0.260	99,779	0.228
Pseudo-IO CPII	87,724	0.360	145,073	0.246	127,057	0.837	97,824	0.485	270,837	0.211	60,914	0.368
Pseudo-IO CPIII	38,595	0.253	49,101	0.319	52,380	0.317	11,700	0.430	179,488	0.598	100,421	0.320
Inv-var CPI	67,752	0.219	67,140	0.330	130,813	0.244	120,163	0.186	159,572	0.260	99,779	0.228
Inv-var CPII	64,390	0.170	151,472	0.212	130,336	0.314	80,912	0.310	287,646	0.136	43,672	0.268
Inv-var CPIII	38,087	0.211	34,045	0.203	49,960	0.147	13,015	0.281	140,336	0.162	68,651	0.201
Closing CPIII:CPI	0.65	0.30	0.84	0.43	0.46	0.37	0.11	0.44	1.29	0.63	1.15	0.36
Closing CPIII:CPII	0.50	0.41	0.39	0.37	0.47	0.88	0.14	0.63	0.76	0.62	1.89	0.46
IO CPIII:CPII	0.61	0.43	0.17	0.48	0.38	0.38	0.19	0.54	0.46	0.24	1.65	0.45
Inv-var CPIII:CPI	0.56	0.30	0.51	0.39	0.38	0.29	0.11	0.34	0.88	0.31	0.69	0.30
Inv-var CPIII:CPII	0.59	0.27	0.22	0.29	0.38	0.35	0.16	0.42	0.49	0.21	1.57	0.34

Comparable areas	Area I		Area II		Area III		Area IV		Area V		Area VI	
	P	CV	P	CV	P	CV	P	CV	P	CV	P	CV
Closing CPI	90,258	0.213	88,206	0.355	139,961	0.240	107,655	0.154	204,773	0.273	77,604	0.205
Closing CPII	128,759	0.377	133,121	0.236	168,430	0.905	79,354	0.406	202,136	0.181	48,866	0.324
Closing CPIII	33,655	0.231	43,224	0.267	45,676	0.299	10,202	0.417	156,513	0.589	87,567	0.303
IO CPII	97,993	0.214	230,048	0.491	222,465	0.367	78,055	0.396	289,709	0.178	40,227	0.356
IO CPIII	37,030	0.381	30,612	0.257	49,370	0.166	14,493	0.368	138,493	0.168	61,458	0.249
Pseudo-IO CPI	118,605	0.239	115,908	0.371	183,918	0.263	141,465	0.188	269,084	0.294	101,976	0.232
Pseudo-IO CPII	169,196	0.393	174,929	0.260	221,327	0.912	104,276	0.420	265,619	0.212	64,212	0.342
Pseudo-IO CPIII	38,595	0.253	49,569	0.287	52,380	0.317	11,700	0.430	179,488	0.598	100,421	0.320
Inv-var CPI	118,605	0.239	115,908	0.371	183,918	0.263	141,465	0.188	269,084	0.294	101,976	0.232
Inv-var CPII	104,455	0.192	182,622	0.231	222,304	0.341	86,776	0.291	278,693	0.136	47,384	0.253
Inv-var CPIII	38,087	0.211	35,067	0.196	49,960	0.147	13,015	0.281	140,336	0.162	68,651	0.201
Closing CPIII:CPI	0.37	0.31	0.49	0.44	0.33	0.38	0.09	0.44	0.76	0.65	1.13	0.37
Closing CPIII:CPII	0.26	0.44	0.32	0.36	0.27	0.95	0.13	0.58	0.77	0.62	1.79	0.44
IO CPIII:CPII	0.38	0.44	0.13	0.55	0.22	0.40	0.19	0.54	0.48	0.24	1.53	0.43
Inv-var CPIII:CPI	0.32	0.32	0.30	0.42	0.27	0.30	0.09	0.34	0.52	0.34	0.67	0.31
Inv-var CPIII:CPII	0.36	0.28	0.19	0.30	0.22	0.37	0.15	0.40	0.50	0.21	1.45	0.32

Comparable areas + like minke	Area I		Area II		Area III		Area IV		Area V		Area VI	
	P	CV	P	CV	P	CV	P	CV	P	CV	P	CV
Closing CPI	90,258	0.213	88,206	0.355	139,961	0.240	107,655	0.170	205,370	0.273	77,604	0.205
Closing CPII	138,707	0.402	133,256	0.226	157,008	0.801	81,537	0.384	202,596	0.181	32,458	0.310
Closing CPIII	40,215	0.249	49,127	0.293	46,563	0.294	12,957	0.366	147,001	0.402	99,422	0.297
IO CPII	109,381	0.234	216,811	0.370	271,419	0.410	55,124	0.240	305,444	0.177	56,343	0.288
IO CPIII	43,275	0.257	40,921	0.218	44,331	0.208	18,409	0.368	151,355	0.159	74,310	0.189
Pseudo-IO CPI	125,923	0.238	123,060	0.370	195,266	0.262	150,194	0.201	286,521	0.293	108,269	0.231
Pseudo-IO CPII	193,516	0.416	185,911	0.250	219,048	0.808	113,757	0.398	282,651	0.210	45,283	0.327
Pseudo-IO CPIII	51,279	0.269	62,642	0.310	59,373	0.311	16,521	0.380	187,443	0.415	126,775	0.314
Inv-var CPI	125,923	0.238	123,060	0.370	195,266	0.262	150,194	0.201	286,521	0.293	108,269	0.231
Inv-var CPII	117,124	0.208	193,659	0.208	256,571	0.367	59,745	0.213	295,114	0.135	50,322	0.217
Inv-var CPIII	46,435	0.186	44,714	0.182	47,340	0.174	17,393	0.265	154,500	0.148	80,123	0.165
Closing CPIII:CPI	0.45	0.33	0.56	0.46	0.33	0.38	0.12	0.40	0.72	0.49	1.28	0.36
Closing CPIII:CPII	0.29	0.47	0.37	0.37	0.30	0.85	0.16	0.53	0.73	0.44	3.06	0.43
IO CPIII:CPII	0.40	0.35	0.19	0.43	0.16	0.46	0.33	0.44	0.50	0.24	1.32	0.34
Inv-var CPIII:CPI	0.37	0.30	0.36	0.41	0.24	0.31	0.12	0.33	0.54	0.33	0.74	0.28
Inv-var CPIII:CPII	0.40	0.28	0.23	0.28	0.18	0.41	0.29	0.34	0.52	0.20	1.59	0.27

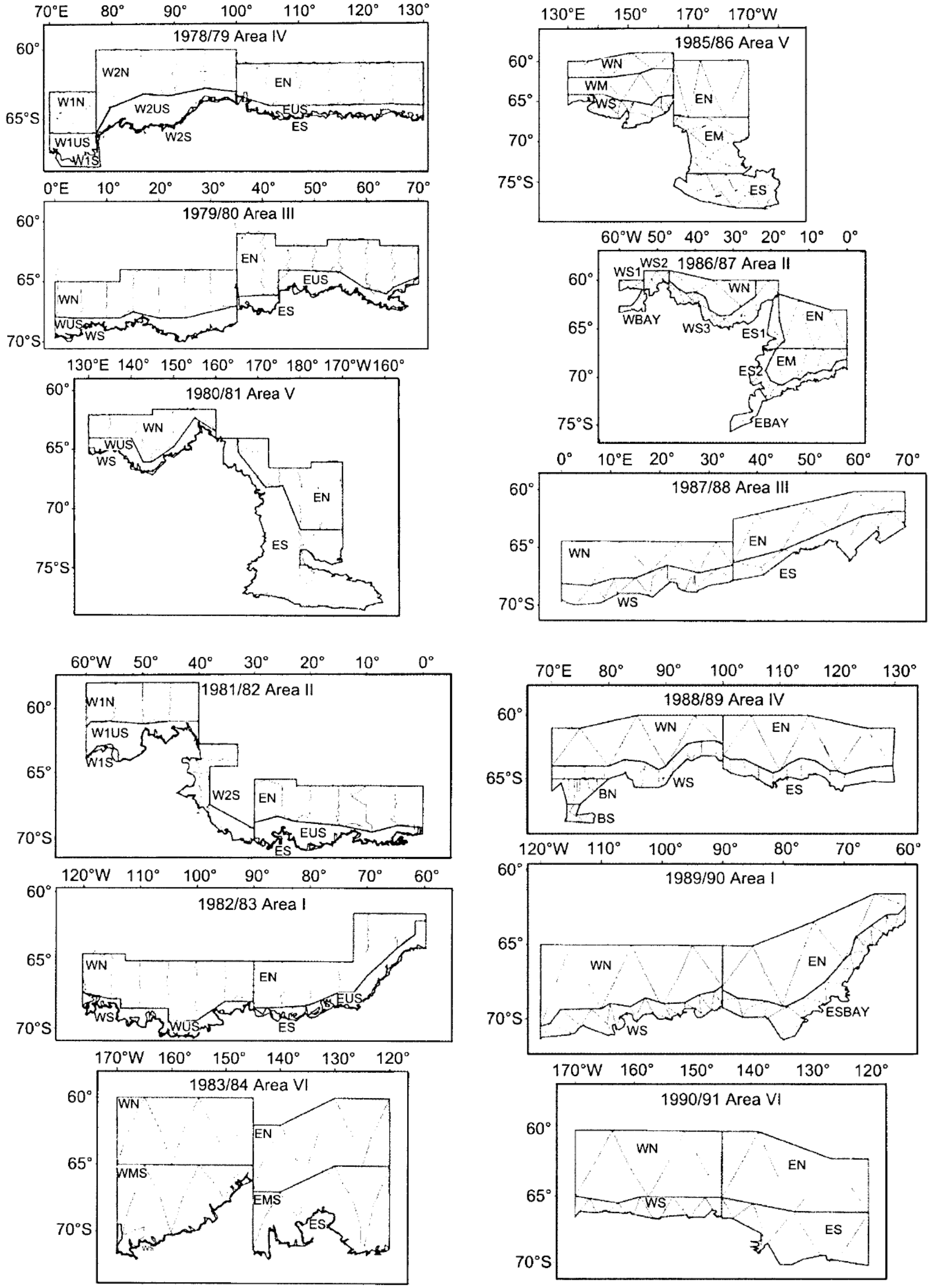

Figure 1a. Survey strata and primary search effort for CPI and CPII sets. Reprinted with permission from Branch and Butterworth (2001a).

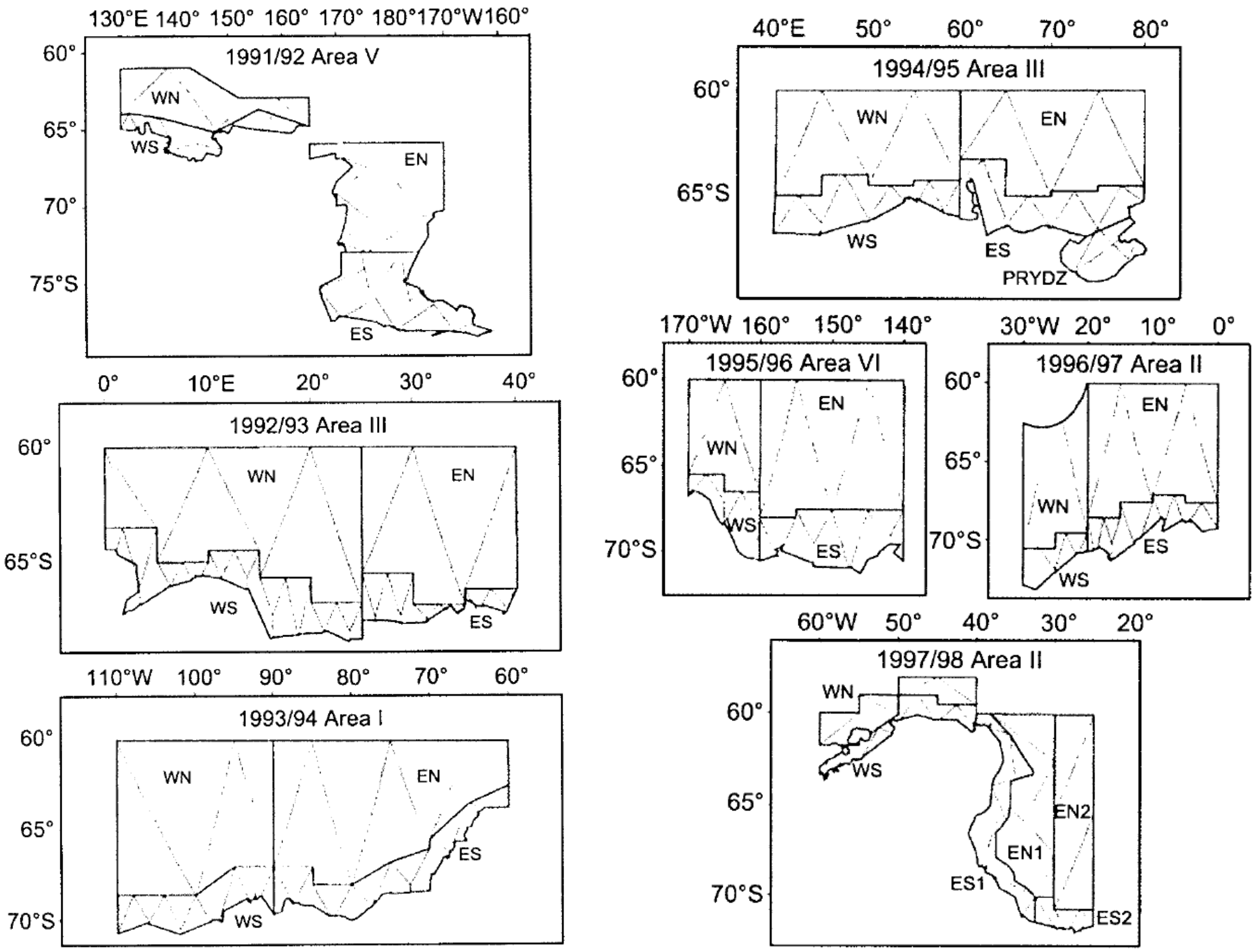

Figure 1b. Survey strata and primary search effort for CPIII from 1991/92 to 1997/98. Reprinted with permission from Branch and Butterworth (2001a).

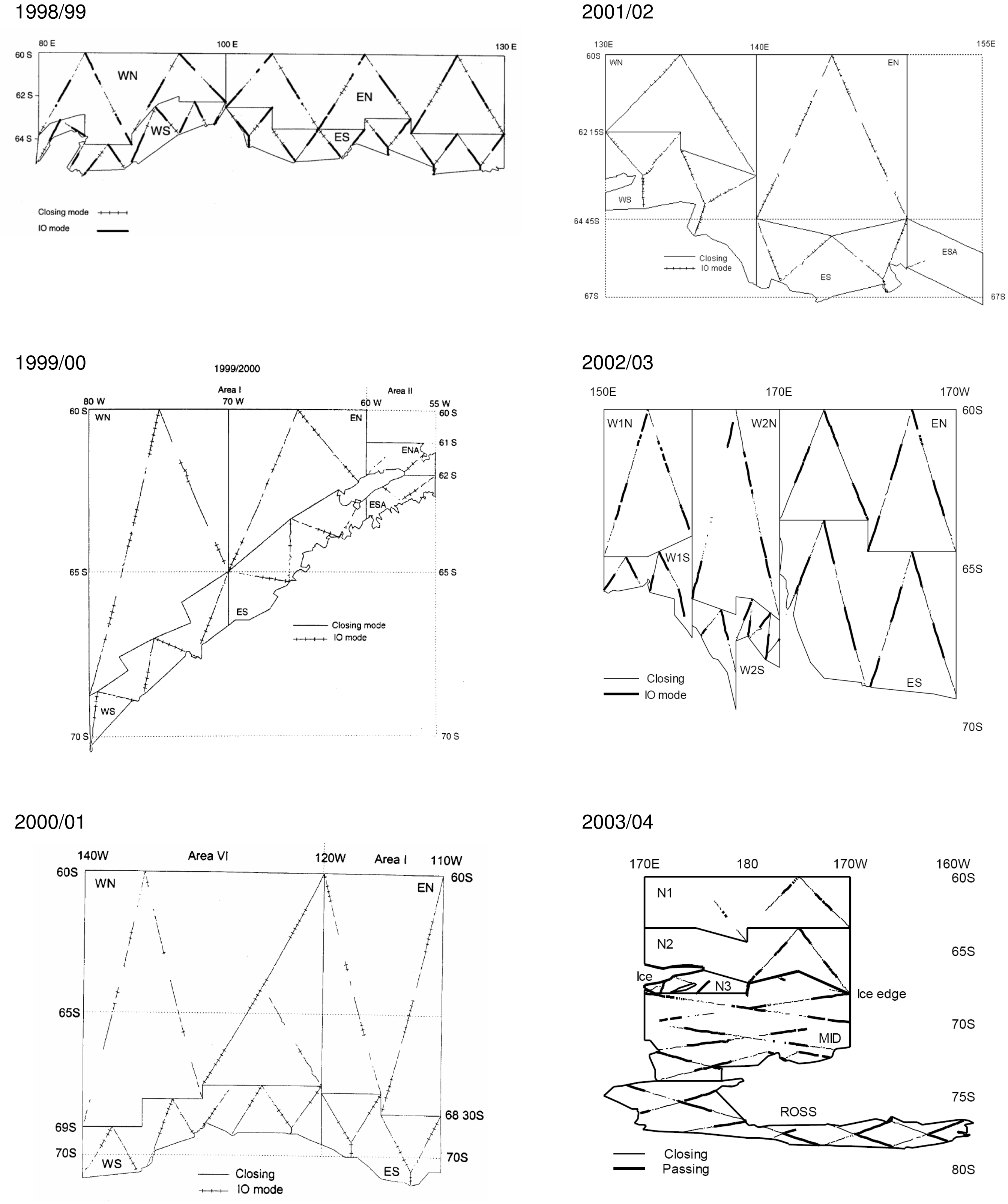

Figure 1c. Survey strata and primary search effort for CPIII from 1998/99 to 2003/04. Reprinted with permission from Burt and Stahl (2001), Burt (2002), Burt and Hughes (2002, 2003, 2004, 2005).