Factors to be considered when using abundance estimates for North Pacific minke whales

Paul R. Wade[1], Russell Leaper[2], Toshio Kasuya[3], and Mike Double[4]
1) National Marine Mammal Laboratory, Seattle, Washington, USA
2) School of Biological Sciences, University of Aberdeen, Tillydrone Avenue, Aberdeen AB24 2TZ, UK
3) 5-30-32-3, Nagayama, Tama, Tokyo, 206-0025 Japan
4) Australian Marine Mammal Centre Science, Australian Antarctic Division, Hobart, Australia

Abstract
One of the primary objectives of the *Pre-Implementation Assessment* of North Pacific Common Minke Whales is to consider abundance estimates that might be used for conditioning the *Implementation Simulation Trials* (*ISTs*). The data need to have sufficient temporal and spatial resolution to allow for estimates at the scale of the sub-areas that would be likely to be used in simulation trials. A variety of surveys have been conducted in different areas at various times by the governments of Korea and Japan. One question is whether the abundance data provide adequate geographic coverage of the entire Region, but another issue to examine is which surveys should be used, taking account of the area and the time of the year the survey occurred. Many of the surveys occur while minke whales are on migration; this presents a particular challenge for deciding which surveys can be appropriately used in concert. Kitakado et al. (2009) propose a method for integrating abundance surveys of minke whales in the Yellow Sea and East Sea/Sea of Japan. Although there is an attempt to restrict the surveys to a limited time period, we still find there is a substantial chance of double-counting due to the possibility of whales counted early in southern surveys migrating north to also be counted during northern surveys that start approximately 20-30 days later. Additionally, we find the proposed large-scale extrapolation of density from surveyed areas into un-surveyed areas unacceptable for an assessment.

Introduction

One of the primary objectives of the *Pre-Implementation Assessment* of North Pacific Common Minke Whales is to consider abundance estimates that might be used for conditioning the *Implementation Simulation Trials* (*IST*s). The data need to have sufficient temporal and spatial resolution to allow for estimates at the scale of the sub-areas that would be likely to be used in simulation trials. A variety of surveys have been conducted in different areas at various times by the governments of Korea and Japan. During the *Pre-Implementation Assessment* one of the specific desired outcomes will be a list of abundance estimates that should be used within each sub-area, if any.

One question is whether the abundance data provide adequate geographic coverage of the entire Region, but another issue to examine is which surveys should be used, taking account of the area and the time of the year the survey occurred. Many of the surveys occur while minke whales are on migration; this presents a particular challenge for deciding which surveys can be appropriately used in concert.

In this review we have not considered the details of the abundance estimation within each survey, such as estimation of g(0), The surveys were largely conducted with observations from a single platform (An et al. 2009; Miyashita et al. 2009), and thus data were not available to estimate g(0) or examine responsive movement. We have also not considered any implications of conducting surveys in passing mode or closing mode. Most surveys were in closing mode except the two most recent Japanese surveys in 2006 and 2007 which used independent observers in passing mode (Miyashita et al. 2009). We have taken the estimates for each survey area as given and only addressed the issues related to combining the areas and extrapolation into un-surveyed areas. In particularly, we review the proposals for combining abundance estimates presented in Kitakado et al. (2009)

Seasonal migration of North Pacific minke whales

Omura and Saikura (1956) analyzed catches from small-type commercial whaling during 1948-1954. The operation had no regulation till 1951, but it was limited to the 6 months of February-July since 1952. They show peaks in minke whale catches moving from Sea of Japan coast of Honshu in March, to northern Kyushu in April, and to the Sea of Japan coast of southern Hokkaido in June (Omura and Saikura 1956, Fig. 18). In the Sea of Japan, the minke whale was the only important target of the fishery (Baird's beaked whale was also taken but was less preferred), so the peaks in catches should represent their migration, although it might be skewed to

some degree by the operation off Sanriku (Pacific coast) in June and July (because the same whaling vessels moved from one ground to another).

Similarly, Pastene et al. (2000) reviewed length and maturity data from catches in the Pacific and describe a migration pattern where females move through sub-area 7 early in spring, arriving in the southern Sea of Ohkotsk (sub-area 11) to feed in May, moving further north in the Sea of Ohkotsk in summer (sub-areas are depicted in Fig. 1). They concluded that males arrive in sub-area 7 later, with many apparently remaining in sub-area 7 in coastal and offshore waters for the summer to feed.

Although bycatch data from Japan indicate minke whales are found in coastal waters year-round, this may just represent different components of the stock(s) migrating through those waters. From small-type commercial whaling catches, Kato (1992) showed that the majority of catches of males from the whaling grounds east of Hokkaido, the southern Sea of Okhotsk, and the northern Sea of Japan (mainly west of Hokkaido) were mature whales, whereas catches further south off Honshu on the Sanriku whaling ground were mainly immature whales. Similarly, the fraction of mature females was much lower at Sanriku compared to the other whaling grounds to the north.

Seasonal trend in abundance surveys

There is a substantial seasonal trend in timing between the southern surveys and the northern surveys, even after removing 3 early surveys (as suggested by the authors of Kitakado et al. (2009)). The surveys in Subarea 5 (Yellow Sea) and the southern part of Subarea 6 (southern part of the East Sea/Sea of Japan) occurred from mid- or late-April until late-May or early-June. The surveys of Subarea 10 and the northern part of Subarea 6 (the northern part of the East Sea/Sea of Japan) occurred from mid- or late-May until mid- or late-June, meaning there is an ~ 1 month lag in the start of the surveys to the north, in the direction the minke whales are thought to be migrating. Therefore, because survey effort migrates in the same direction and perhaps over a similar period as the whales there is the possibility of double-counting if abundance estimates from these regions are added, as has been done in Kitakado et al. (2009).

Little data exist on migration travel rates for minke whales, but substantial data now exist for humpback whales from satellite telemetry, which show they can travel 60-100km per day (Zerbini et al, 2006, Zerbini et al, in press, Garrigue et al in press, Hauser et al. in review). These travel rates are consistent with satellite tracking of two minke whales off northern Norway which moved an average of 53 and 66km between daily positions (Heide-Jørgensen et al., 2001). Using the 60-100km a day range one would expect it to take 16-27 days for a minke whale to travel from the southern tip of Honshu to west of Hokkaido (~1600km), and 22-38 days from the southern tip of Honshu to the northern part of Subarea 10 (~2250km). Given there is about a 20-30 day lag between the start of surveys in Subareas 5 and 6-south, and the start of the surveys in Subareas 6-north and 10, it is clear there is a strong likelihood of double-counting, so those sets of surveys cannot be added to get abundance for the population.

Some evidence for seasonal patterns in distribution can be gained by examination of bycatch rates. SC/61/NPM4 Table 2 gives bycatch data for Area 6 which suggests maximum numbers in April declining through the summer to a minimum in September and October. Additionally, bycatch data in Subarea 7 (Pacific coast of northern Honshu) show an increasing proportion of J-stock individuals from ~April to a peak in ~October (SC/61/JR5), indicating that migration is occurring during the period of time that the abundance surveys take place. Furthermore, it is known that during commercial whaling the distribution of the whaling fleet moved north within the Sea of Japan in concert with this movement north of the whales. This overall pattern of movement to the north is consistent with concerns over double counting of migrating animals.

A suggestion for the assessment would be that the early surveys could be added together (survey areas 5E, 6WS, and 6ES) for an abundance for that early period in those areas, and the later surveys could be added together (survey areas 6EN, 10E, and 10W) for a later period. If the operating model used in the assessment has sufficient resolution (both temporally and spatially), the model could be fit to both abundance estimates. However, given the likely northerly migration of minke whales over the survey period it is inappropriate to use the sum of the two numbers as an abundance estimate for the stock.

It should also be noted that given possible genetic differences seen between Korean and Japanese waters in the East Sea/Sea of Japan (Lavery et al. SC/57/NPM5, Kanda et al. SC/58/NPM2), the total abundance for the region may apply to more than one stock. Further, given that the majority of the abundance for the later period comes from the very northern part of Subarea 10, the possibility exists that "O-type" minke whales also occur in that area, so that the collection of data to determine possible mixing proportions in this region is important.

Extrapolation of abundance into un-surveyed areas

The extrapolation of average density from surveyed areas into large un-surveyed areas is inappropriate for the assessment. Limited extrapolation may be appropriate in some cases to improve an assessment. However, the recommendations of Kitakado et al. (2009) go beyond a limited extrapolation. In their calculation abundance is extrapolated for all of Sub-areas 5 from a survey of 13% of the Sub-area (due primarily to the inability to survey in waters of China and North Korea). Similarly, only 56% of Sub-area 6 and 68% of Subarea 10 were surveyed, meaning that only ~48% of the total area of the Yellow Sea and East Sea/Sea of Japan has been surveyed (% calculated from Table 3 of Kitakado et al. (2009)). The distribution of minke whales is not uniform throughout the survey areas, and there are substantial survey areas that show essentially no minke whales, so it is not appropriate to extrapolate density into large un-surveyed areas. Such extrapolation is not allowed for abundance estimates used for the RMP or for associated *Implementation Simulation Trials*, and we see no compelling scientific justification for using such extrapolations in any assessment.

An additional problem is associated with extrapolation of density for a species that is migrating – this can be seen in the in the May-June model, where the surveys conducted in block 6ES are not used because of the early timing of these surveys. However, this block is still included in the extrapolated estimates based on data from 6WS and 6EN. This results in an assumed higher density in 6ES later in the season than was actually observed in the early season surveys. The implication from the extrapolation that density in block 6ES increases through the season would not be consistent with an overall northward migration.

Trends in abundance

We note that analyses in Kitakado et al. (2009) estimate a negative trend of 5% (for a subset of surveys) or 7% (for all surveys) in minke whale abundance in the East Sea/Sea of Japan, though the precision of the estimates is not great enough to be significantly different from 0.0. It was also noted there appears to be a declining trend in abundance in Korean waters in the East Sea from the repeated surveys there (which may be driving the overall trend in Kitakado et al. (2009)); although no specific test of trend in only Korean waters was performed. The possibility of a declining trend is of great concern given the substantial bycatch that occurs in the East Sea/Sea of Japan, and we suggest an analysis be conducted to examine whether there was a significant trend in minke whale abundance along the eastern coast of Korea. Further examination of the overall trend in minke whale abundance in the East Sea/Sea of Japan is also recommended.

Reported bycatch of minke whales in Korean waters was ~80 whales per year in recent years (SC/59/, SC/60/ProgRepKorea). Genetic analysis of market samples in Korea suggest true mortality from human causes may be ~twice that number (Baker et al. 2007). Reported bycatch of minke whales in Japanese waters was around 130 whales per year in recent years (e.g,, SC/59, SC/60/ProgRepJapan); a majority of this bycatch has been genetically identified as individuals from the Sea of Japan population ("J-stock", e.g., SC/61/JR5, SC/61/ForInfo47). If minke whales in this region are declining, it is possible this decline could be driven fully or partially by this level of bycatch.

Conclusions

In summary, Kitakado et al. (2009) propose a method for integrating abundance surveys of minke whales in the Yellow Sea and East Sea/Sea of Japan. Although there is an attempt to restrict the surveys to a limited time period, we still find there is a substantial chance of double-counting due to the possibility of whales counted early in southern surveys migrating north to also be counted during northern surveys that start approximately 20-30 days later. Additionally, we find the proposed large-scale extrapolation of density from surveyed areas into un-surveyed areas unacceptable for an assessment. We make the following specific conclusions and recommendations.

1. Abundance from different surveys can only be combined for early surveys in Subareas 5E, 6WS, and 6ES or for later surveys in Subareas 6EN, 10E, and 10W.

Simple un-weighted sums of surveys for these two areas are:

a. Yellow Sea/southern Sea of Japan (5E, 6WS, 6ES)	2,112
b. northern East Sea/Sea of Japan (6EN, 10E, and 10W)	4,293

We stress that these two estimates cannot be combined – the first applies to an early period (late-April through late-May/early-June) and the second applies to a later period (late-May through late-June), with an average lag of ~20-30 days, and it is likely that whales have migrated from the southern area to

the northern area during the lag that occurs before the start of the northern surveys. We calculate simple un-weighted sums here, but more properly these should be based on sums of weighted averages within each survey block.

2. Extrapolation into un-surveyed areas should not be done for the assessment.

Kitakado et al. (2009) extrapolates density from surveyed areas into substantial un-surveyed areas. The surveyed area represents ~48% of the total area of Subareas 5, 6, and 10. We cannot base an assessment on abundance that is not adequately supported by data.

3. We have great concern for the estimated negative trend of minke whales in the Yellow Sea and East Sea/Sea of Japan

Given the high level of bycatch takes in both Korea and Japan, we have great concern about the estimated negative trend of ~5% or 7%, although the data are not precise enough to determine whether the trend is statistically significant. We recommend a trend analysis of the consistent surveys off the east coast of Korea and further exploration of analysis methods of the combined surveys. Further, we stress the importance of the continuation of surveys in the future in order to better determine trends in abundance of minke whales in the Yellow Sea and East Sea/Sea of Japan.

Literature Cited

An, Y.R., Kim, Z.G., Choi, S.G. and Park, K.J. 2009. Abundance estimation of common minke whales in the Yellow Sea and the East Sea using the Korean sighting data from 2000 to 2008 with g(0)=1. Paper SC/61/NPM2 presented to IWC Scientific Committee, Madeira, Portugal.

Garrigue, Claire, Alexandre N. Zerbini, Ygor Geyer, Mads-Peter Heide-Jørgensen, Wakao Hanaoka, and Phil Clapham 2010. Movements of Satellite-Monitored Humpback Whales from New Caledonia Journal of Mammalogy 91(1):109-115

Hauser, N., Alexandre N. Zerbini, Ygor Geyer, Mads-Peter Heide-Jørgensen, Phil Clapham. 2010. Movements of satellite-monitored humpback whales, Megaptera novaeangliae, from the Cook Islands. Marine Mammal Science *in press*.

Heide-Jørgensen, M.P., E.S. Nordøy, N. Øien, L.P. Folkow, L. Kleivane, A.S. Blix, M.V. Jensen and K.L. Laidre. 2001. Satellite tracking of minke whales (*Balaenoptera acutorostrata*) off the coast of northern Norway. Journal of Cetacean Research and Management 3:175-178.

Kanda, N., Park, J.Y., Sohn, H., Kim, Z.G., Goto, M. and Pastene, L.A. 2006. Preliminary microsatellite analysis of bycaught J-stock minke whales from Japan and Korea. Paper SC/58/NPM2 presented to the IWC Scientific Committee, June 2006, St Kitts and Nevis, WI. 7pp.

Kato, H. 1992. Body Length, reproduction, and stock separation of minke whales off Northern Japan. Rep. Int. Whal. Commn. 42:443-453.

Kitakado, T., An, Y., Choi, S., Miyashita, T., Okamura, H., and Park, K. 2009. Integration of abundance estimates for common minke whales in sub-areas 5, 6 and 10 using sighting data from Japanese and Korean surveys. SC/61/NPM6.

Lavery, S., Baker, C.S., Dalebout, M.L., Funahashi, N., Ma, Y-N., Robertson,KL., Brownell, R.L, JR., Cipriano, F. 2005. Hidden population structure and undocumented exploitation of North Pacific minke whales inferred from genetic analysis of Japanese and Korean market products. Paper SC/57/NPM5 presented to the IWCScientific Committee, June 2005, Ulsan, Korea.12pp.

Miyashita, T., Okamura, H. and Kitakado, T. 2009. Abundance of J-stock common minke whales in the Sea of Japan using the Japanese sighting data with *g*(0)=1. 10pp. Paper SC/61/NPM2 presented to IWC Scientific Committee, Madeira, Portugal.

Omura, H. and Sakiura, H. 1956. Studies on the little piked whale from the coast of Japan. Sci. Rep. Wales Research Inst. (Tokyo), 11:1-46.

Pastene, L.A., Goto, M. and Fujise, Y. 2000. Review of the studies on stock identity in the minke whale Balaenoptera acutorostrata from the North Pacific. SC/F2K/J1

Zerbini, A. N. 2006. Satellite-monitored movements of humpback whales (*Megaptera novaeangliae*) in the southwest Atlantic Ocean. Marine Ecology Progress Series 313:295–304

Zerbini, A.N., Andriolo, A., Heide-Jørgensen, M.P., Moreira, S., Pizzorno, J.L., Maia, Y.G., VanBlaricom, G.R. and DeMaster, D.P. in press. Migration and summer destinations of humpback whales (*Megaptera novaeangliae*) in the western South Atlantic Ocean. Journal of Cetacean Research and Management (Special Issue).

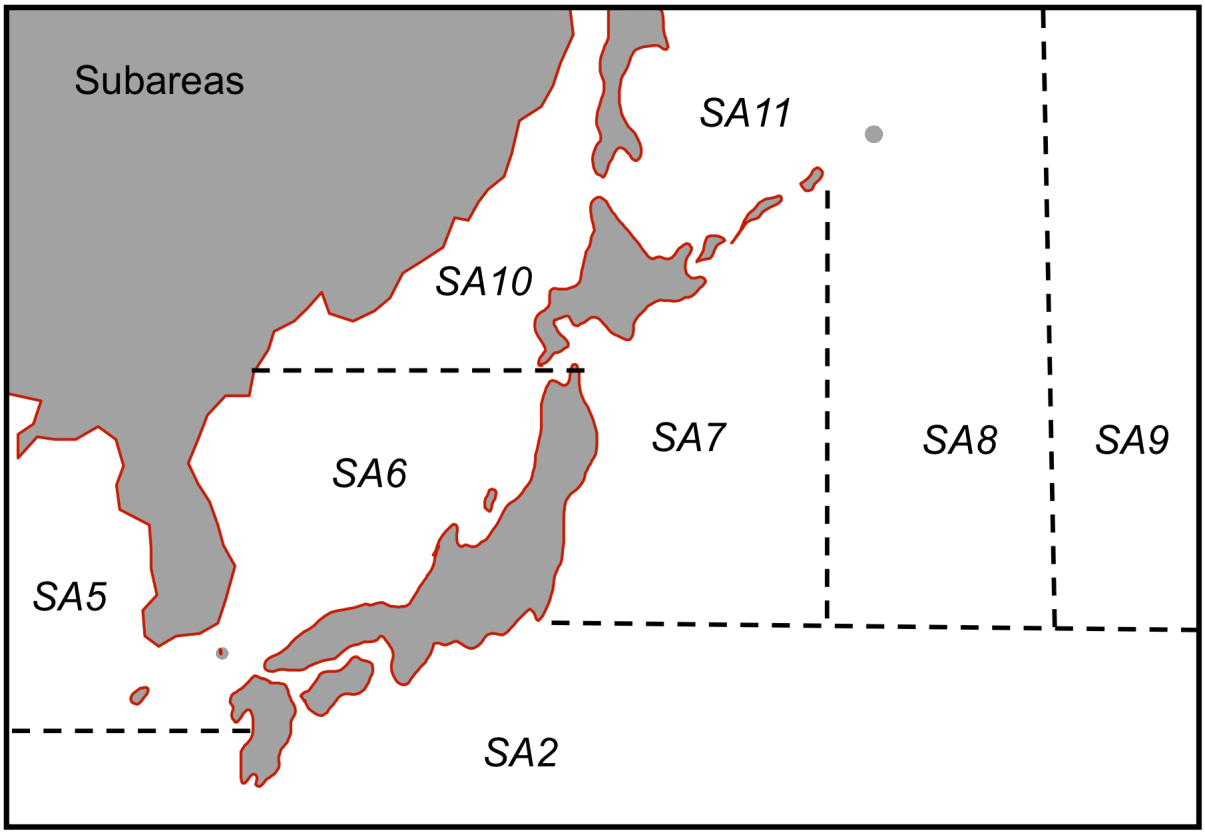

Figure 1. Sub-areas used in the Implementation Simulation Trials.