# A comparison of observed surfacing rates in minke whales between surveys and VHF tagged animals

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## Abstract

We compare surfacing rates of VHF-tagged minke whales with the surfacing rate among individuals encountered in the Norwegian line transect surveys in the Northeastern Atlantic for the period 2002-2007. The question is whether VHF-data are representative for the diving behaviour of minke whales in the survey area and period, or whether the average surfacing rate estimated from VHF-tracking is negatively biased. To account for the selection bias inherent in the surveys due to clustering of surfacings and individual heterogeneity in average surfacing rate, we use simulation. We find no evidence of negative bias in the VHF-based estimate of average surfacing rate, and hence not evidence for a positive bias in the resulting abundance estimate. This is consistent with what has been found previously for the survey period 1996-2001.

## Introduction

The analytical method used to estimate abundance of Northeastern Atlantic minke whales relies on information about the diving behaviour of minke whales (Bøthun et al. 2009). Dive time information has been obtained from VHF tagged animals (Øien et al., 2009), but the relevance of these dive time data to animals encountered in the sighting surveys has been questioned (IWC, 2008). The main concern is that negative bias in the VHF-based surfacing rate will induce a negative bias in the effective strip half-width, which again will lead to an upwards biased abundance estimate.

The protocol for the Norwegian minke whale line transect surveys (Øien, 1995) specifies that individual whales shall be tracked, and the time point of each surfacing shall be recorded. In principle, this allows the surfacing rate to be estimated directly from the survey data. However, there is a bias in the selection of individuals to be inspected (towards detection of frequent breathers), so one cannot directly compare inter-surfacing times in the surveys with the VHF data. To circumvent this problem Skaug and Bøthun (2003) simulated artificial line transect data with whales diving according to the VHF data, and on top that ran an observer making detection according to the estimated detection function. Skaug and Bøthun (2003) then compared the mean

inter-surfacing times for detected individuals in the real and simulated data, and found that the surfacing rate is higher in the VHF data. Since an upward biased VHF-based estimate of surfacing rate will lead to a negative bias in the abundance estimate this result is of less concern from a whale conservation perspective.

We repeat the same type of analysis to survey data from the period 2002 – 2007 (Bøthun et al., 2009).

## Methods

Whales tracks consisting of only a single surfacing were discarded. A track consisting of $n$ surfacings gives rise to $n$-1 dive times. Denote by $T_i$ the mean dive time for the $i$'th individual.
The simulation program described in Skaug et al. (2003) can generate artificial survey data. The main input to the simulation program is the surfacing rate and the shape of the detection function. To be precise, the simulation program takes as input the full set of VHF dive time series, and samples short stretches of these randomly to generate the diving behaviour of the simulated whales. We used the estimated detection function (hazard probability model, to be precise) from Bøthun et al. (2009). Since, at least in theory, the simulated data have been generated by the same mechanism that generated the real survey data, comparison of real and simulated should provide information about the representativeness of VHF dive time series.

## Results

The survey data 2002-2007 contained in total 505 whale tracks consisting of two or more surfacings. We simulated 2960 tracks (platform A, only). Table 1 shows a frequency table for $n$ (the number of surfacings per track) both for survey data and simulated data. Table 2 shows the mean and median of $T_1,\ldots, T_m$ for both survey data and simulated data. (Recall that $T_i$ denotes the average dive time for the $i$'th whale track.) In both tables results from the survey period 1996—2001 taken from Skaug and Bøthun (2003) are included for comparison.

## Discussion

Table 1 show that there are more long tracks in the survey data than there are in the simulated data. A partial explanation for this is that some whales have been tracked behind the vessel in the surveys, while in the simulations tracking always stop when the whale is passed abeam. Another possible explanation is responsive behavior of whales in the surveys as they may increase their surfacing rate at short distance.

The VHF-tagged animals have an average dive time of 77 seconds (Øien et al., 2009). When the same dive time series are fed into the simulation program, the average dive times among 'sighted animals' is 27.5 seconds (Table 2). This shows that the selection bias (towards detecting high frequency breathers, and towards whales in breathing mode when passed) is substantial.

The main finding of this paper is that the average surfacing rates of minke whales in the survey area appears lower than the surfacing rate of the VHF-tagged animals. This conclusion follows directly from Table 2 (from both the Median and Mean statistics for dive times). This gives support to the claim that the average surfacing rate estimated from the VHF-data are not negatively biased. The same conclusion was drawn by Skaug and Bøthun (2003) for the 1996-2001 data. A potential source of bias is that observers may miss individual cues in a track in the surveys. This would lead to a negative bias in surfacing rate observed in the surveys. Since a similar mechanism is not built into the simulations it could affect the conclusions drawn in the analysis. However, previous application of a visualization program designed for doing manual duplicate identification to the 1995 and 1996-2001 did not identify many clear instances of "wholes in tracks", and it is believed that this effect alone cannot explain the differences in Table 2.

Our conclusion is that there might be some positive bias in the surfacing rate estimated from VHF-tagged animals. This, in turn, would imply that the abundance estimates presented in Bøthun et al. (2009) are negatively biased. This conclusion follows from the fact the abundance estimate is a decreasing function of the mean surfacing rate given as input to the estimator used by Bøthun et al. (2009).

## References


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## Tables

| **Period** | | ***n=2*** | ***n=3*** | ***n=4*** | ***n=5*** | ***n=6*** | ***n=7*** | ***n=8*** | ***n>9*** |
|---|---|---|---|---|---|---|---|---|---|
| 1996-2001 | Simulations | 0.619 | 0.256 | 0.088 | 0.027 | 0.008 | 0.002 | 0.001 | 0.000 |
| | Survey | 0.52 | 0.224 | 0.119 | 0.058 | 0.033 | 0.016 | 0.009 | 0.023 |
| 2002-2007 | Simulations | 0.521 | 0.286 | 0.121 | 0.049 | 0.014 | 0.006 | 0.001 | 0.002 |
| | Survey | 0.459 | 0.248 | 0.135 | 0.065 | 0.042 | 0.028 | 0.012 | 0.012 |

**Table 1** Proportion of tracks consisting of *n* separate surfacings.

| **Period** | | **Simulations** | **Surveys** |
|---|---|---|---|
| 1996-2001 | Median($T_i$) | 21.5 | 35.0 |
| | Mean($T_i$) | 31.2 | 46.3 |
| 2002-2007 | Median($T_i$) | 16.0 | 31.2 |
| | Mean($T_i$) | 27.5 | 47.8 |

**Table 2** Comparison of simulated and observed dive times (in second). Here, $T_i$ denotes the mean dive time for the *i*'th individual (calculated across two or more available surfacings).