SC/68C/ASI/04

Sub-committees/working group name: ASI

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ABSTRACT

We present an estimate of abundance of common minke whales in the northeast Atlantic based on data collected over the period 2014-2019. The abundance estimate for the total covered area has increased by about 50 % compared to the three preceding survey periods, i.e. from 101 000 to about 150,000 minke whales. The increase is attributed to increases within the Small Management Areas CM, EB and EN and decreases of abundance within EW and ES. Within the Eastern Medium Area, the recent comparable estimate is 15 % higher than in the previous three cycles, i.e. about 105,000 animals. However, within this region there have been south- and eastwards distributional shifts from the Norwegian Sea and the Svalbard area to the Barents Sea and the North Sea.

MINKE WHALES, NORTH ATLANTIC, ABUNDANCE ESTIMATE, VESSEL SURVEY

INTRODUCTION

Common minke whales (*Balaenoptera acutorostrata acutorostrata*) are widely distributed throughout the North Atlantic. They are especially abundant over continental shelf structures and their slopes. They are thought to undergo an annual cycle which includes feeding migrations in summer to high latitudes and an assumed winter stay in warmer waters where mating and calving take place. The Norwegian small-type whaling with minke whales as the main target species developed from the 1920-ies onwards. It started as an operation in Norwegian coastal waters but expanded later to wide areas in the northeast Atlantic. After a five-year break in the minke whaling, initiated by uncertainty about the status of minke whales in the Northeast Atlantic, whaling was reopened in 1993 under regulation by the Revised Management Procedure developed by the IWC Scientific Committee. This management regime requires abundance estimates on a regular basis, and thus sighting surveys have been established and conducted in recent years to collect data for these estimations. Results from surveys in 1988 and 1989 combined and from a survey in 1995 were presented in Schweder et al. (1997). After 1995, annual partial surveys have been conducted that over a six-year period provide data for estimating total abundance in the northeast Atlantic (Skaug et al. 2004, Bøthun et al. 2009, Solvang et al. 2015). Here we present an estimate of minke whale abundance in the northeast Atlantic based on data collected over the years 2014-2019. The total abundance over the surveyed area in this period is 149,722 minke whales with a coefficient of variation c.v. = 0.15 when additional variance due to the multi-year survey design is accounted for.

MATERIAL AND METHODS

Data collection 2014-2019

Over the period 2014-2019 annual surveys were conducted that covered the Northeast Atlantic from the North Sea (southern boundary 52ºN) to the ice edge, and from the Greenland Sea in the west to the Barents Sea in the east (Figure 1). The survey area is divided into *Small Management Areas* as implemented in Berlin 2003 (IWC 2004) and further divided into survey strata as shown in Figure 1.

In 2014 the survey cycle was started by covering the Svalbard area (*Small Management Area* ES) and in 2015 the eastern Norwegian Sea, the *Small Management Area* EW was covered. In 2015 parts of the Jan Mayen area was also covered as an extension to the NASS-2015 sighting survey (Øien 2016), however, these data have not been included in the estimation process described in this paper. In 2016 an ordinary coverage of the areas around Jan Mayen, the *Small Management Area* CM, was conducted; in 2017, the *Small Management Area* EB was covered, in 2017 the *Small Management Area* EB, the Barents Sea, in 2018 the North Sea, *Small Management Area* EN, and finally in 2019 again the *Small Management Area* ES. The stratum block EW4 (Figure 1) was not covered in 2015 when the *SMA* EW was the main target of the survey. EW4 was, however, covered in 2018 and has not been surveyed in any of the previous Norwegian surveys due to weather conditions under time constraints.

Whales were searched by naked eye from two platforms each manned with two observers. The platforms were designed to be independent by being visually and audibly separated. The upper platform, referred to as platform A, was typically a barrel on the mast and the lower platform, platform B, was an arrangement on the wheelhouse roof. Usually the two platforms were approximately above each other; otherwise the barrel was in a stern mast. The observers worked in teams of two on two-hour shifts and there were four teams on each vessel.

The survey and sightings protocols are detailed in Øien (1995). The main points in the procedures were: Primary vessel searching speed was intended to be 10 knots and the surveys were conducted in passing mode. When searching, one of the observers in the team was instructed to scan the port 45º sector from the transect line while the other was to scan the starboard 45º sector. Sightings were made outside these sectors and all initial sightings before abeam have been used in the analyses. Acceptable conditions for primary searching were adapted to minke whale as the target species and defined as meteorological visibility greater than 1 km and Beaufort sea state of 4 or less.

Each observer was equipped with a microphone with a push button. All microphones and buttons were connected to a central computer also equipped with a GPS unit. Time delay due to software and hardware is expected to be less than one second for initial sightings and for resightings there is no time delay. For each sighting, species, radial distance as estimated by eye, angle from the transect line as read from an angle board, school size and swimming direction were reported. If the species was assumed to be a minke whale, specific tracking procedures were followed, as the observer then tried to follow the whale and report the positional data (radial distance, angle) of all its surfacings until the whale passed, or was assumed to have passed, behind abeam. All sightings and resightings received a time and position stamp from the GPS unit. For the minke whale analyses presented here, the units of observation are the tracks of observed surfacings.

The selection criteria for sightings used in the analyses are that they have been recorded from platform A or B when in primary search mode, the species has been confirmed and the initial sighting has been done before abeam. In addition, sightings have been truncated by confining radial distance $r \in [100\text{m}, 2000\text{m}]$.

Data on weather conditions, Beaufort sea state, sightability and glare were recorded regularly on an hourly basis and in addition when conditions had changed notably. After some exploration, certain levels of these covariates were combined (Table 1). As in previous applications, individual observers were grouped into three categories according to their ability to detect whales at long distances, based on a general impression by team leaders. From this list, all combinations of observers were classified as either *long* or *short* according to their presumed ability to detect minke whales at long distance.

Abundance estimation

The basic observational units, the minke whale tracks, from the two platforms A and B were compared for matching by an automatic routine (duplicate identification rule) that has as its criterion difference in timing, bearing and radial distances (Schweder et al. 1997, Skaug et al. 2004, Bøthun & Skaug 2009). Before the matching, missing values of radial distance and and/or angle are imputed by interpolation between adjacent surfacings and taking into consideration the movement of the vessel. An initial sighting has three possible outcomes which are: (1) seen by platform A only; (2) seen by platform B only; (3) seen by both simultaneously. If one platform detects the whale prior to detection by the other platform, it sets up Bernoulli trials where the outcome is seen or not seen by the other platform.

A hazard probability model is used as described in Skaug et al. (2004), where parameters are estimated by maximizing the likelihood based on the observed data. In earlier estimation processes, for example for the sampling periods 1996-2001 (Skaug et al. 2004) and 2002-2007 (Bøthun et al. 2009), a simulation model which took care of bias correction for measurement errors, duplicate identification errors and clustering was included. Due to its complexity, it was abandoned in favour of other methods as applied to the 2008-2013 data set (Solvang et al. 2015). Measurement errors were investigated based on experiments conducted during the 2008-2013 survey cycle (Solvang et al. 2015, Solvang et al. 2021) and led to the decision to use the relative position data as recorded, i.e. uncorrected. Clustering has been taken care of through the variance estimation process (Skaug & Solvang 2015).

For the chosen covariate model, the parameter estimates were used for calculating the effective strip half widths w_A and w_B. These are in turn used to obtain an abundance estimate by survey block:

$$N = \frac{n_A + n_B}{2(w_A + w_B)L} Area$$

where n_A and n_B are the total number of sighted whales from platforms A and B, *L* is the realized transect length, and *Area* is the area of the survey block.

The quantities w_A and w_B are obtained from the fitted hazard probability model, which is parameterized using a GLM approach as follows (see Skaug et al. 2004 for details): The radial distance at which the hazard probability has dropped by 50% is exp(η_r), where η_r is a linear predictor. The linear predictor consists of the intercept β_r and covariate effects. Similarly, there is a linear predictor associated with the effect of sighting angle (intercept β_θ). The hazard probability at the origin ($r = 0$) is parameterized as $\mu = [1+\exp(-\beta_\mu)]^{-1}$.

The hazard probability model involves one additional parameter, the surfacing rate intensity α, which is determined from external data. For that purpose, we used dive time data collected by radio-tagging of 20 minke whales (Øien et al. 2009) over the period 2001-2008. The mean surfacing rate α was estimated from those data, and where sea state information was available, truncated for Beaufort > 4. The estimate is 45.78 blows/hour, which gives the parameter $\alpha = 0.0127$.

The variance of the abundance estimates has been calculated using the approach described in Skaug & Solvang (2015) and applied in previous estimations (Solvang et al. 2015). The inter-annual variation in spatial distribution (additional variance) of the minke whales has been included as in earlier estimates (Skaug et al. 2004, Skaug & Solvang 2015).

RESULTS AND DISCUSSION

Over the survey period 2014-2019 a total effort of 34 625 km was conducted (Table 2, Figure 2). The total survey area was 3,921,389 km^2.

A total of 1265 sightings of groups (sum platform A and B) were made during primary search effort. They were distributed all over the survey areas although at varying densities (Figure 2). Characteristics of the collected distance data are shown in Figure 3.

The diagnostic plots generally show a good relationship between distributions and model predictions, but a lack of fit is observed in the perpendicular distance distribution close to the trackline (Figure 3, upper row), and for the Bernoulli trials in Platform B (Figure 4). Most sightings were made within a 1000 m strip on each side of the transect line. The sighting angle distributions are qualitatively in accordance with the instruction given to the observers of primarily covering the 45° sector from the trackline. In Figure 4 the estimated success probabilities by radial distance for the Bernoulli trials are shown.

Table 1 describes the covariates collected during the surveys and how they have been aggregated for the analyses. The results for a selection of covariate models are shown in Table 3. Based on these results the model with linear predictor η_r = B + G + Ve + T was chosen to be used for the abundance estimation. Parameter estimates are shown in Table 4. Abundance estimates are given by survey block in Table 2. Estimates for the IWC Small Management Areas were calculated by combining the contributions from the appropriate survey blocks (Tables 2 and 5). There are two estimates for the Svalbard area ES: one each for the years 2014 and 2019 (Table 2). The 2014 estimate represents a decrease in abundance compared with the 2008-2013 estimate, and in 2019 a further decrease was seen. A decrease was also seen in the Norwegian Sea (EW). On the other hand, large increases were seen in the Barents Sea proper (EB) and in the North Sea (NS). These changes in SMA abundances probably reflect distributional changes over the Northeast Atlantic and may also be discussed in connection with Icelandic and Faroese surveys (Pike et al. 2020). For the purpose of providing a combined Medium Area estimate for E, the 2014 and 2019 estimates for ES effort weighted into the combined estimate of 19 140 (cv 0.111). The stratum EW4 in the Norwegian Sea was not included in the E estimate of Table 5 to make it comparable to previous estimates since that stratum has never been covered earlier in the Norwegian surveys. The estimate for the Eastern North Atlantic Medium Area in the RMP terminology is 104 692 (Table 5) with an additional variance corrected cv = 0.17. The total estimate for the survey area, including all surveyed strata and a combined estimate for the ES *SMA* is 149 722, with a cv corrected for the multiyear survey pattern equal to 0.15.

In previous analyses, a simulation approach was used to correct bias. However, this correction procedure has had a modest impact on the input estimates based on the survey cycles 1996-2001 and 2002-2008; -2.5 % and -3.7 %, respectively. The demanding bias correction procedure has therefore in later applications been substituted by other approaches. Firstly, measurement error has not been included in the estimations. The reason for this is that an analysis of the experimental data (Solvang et al. 2015, 2021) showed that the abundance estimates taking into account the measurement error are larger than the abundance estimates calculated without any measurement error correction. Secondly, the Neyman-Scott process used previously to account for clumping of animals has been replaced by the Markov modulated Poisson process to estimate variance in whale counts on individual transect legs (Skaug & Solvang 2015). The approach has been applied to the 1996-2001 survey cycle to validate it towards the simulation method. The outcomes have been discussed in Skaug & Solvang (2015). It has also been shown in two different studies that ignoring animal clustering leads to an upwards bias in the effective strip half width, and hence a negative bias in the abundance estimate. The first of these studies (Langrock, Borchers et al. (2013), Table 2) used only single platform data, while the second (Skaug, Schweder et al. (2009), Table 3, Model 2).

The point estimates of total abundance in the ***Eastern Medium Area*** have been very similar over the survey periods 1996-2001, 2002-2007 and 2008-2013 but show a 15 % increase in the 2014-2019 survey period. The increase is especially attributed to *SMA* increases in the Barents and North Seas at the expense of decreases at Svalbard (ES) and in the Norwegian Sea (EW). But it is remarkable that the transition to an eastern and southern distribution has gone through temporary increases in abundance precisely at Svalbard and in the Norwegian Sea. Such shifts in overall distributions are well known and discussed from long-term series of catch statistics (Øien et al. 1987, Skaug et al. 2004).

The minke whale abundance in the total survey area (Figure 1) is about 50 % higher than in the three previous survey cycles. Some of the increase (less than 10 %) can be attributed to the coverage of the stratum EW4 north of the Faroe Islands which was not covered in the earlier surveys. The increased abundance in E accounts for a further 15 %, and the remaining 25 % of the increase have been in *SMA* CM, the Jan Mayen area, which had its highest recorded abundance (Table 5) over all the survey cycles in the 2014-2019 cycle. The large shifts also seen in CM may indicate that the adjacent Medium Areas E and C share a common minke whale population.

CONCLUSION

The point estimate for the total survey area has increased considerably. The increase has occurred within the Small Management Areas CM (Jan Mayen), EB (the Barents Sea) and EN (the North Sea) while a decrease has been observed within EW (the Norwegian Sea) and ES (Svalbard). Within the E Medium Area, the point estimate is higher than in the previous three cycles. However, there are signs of a south- and eastwards distributional shift within this region from the Norwegian Sea and Svalbard area to the Barents and North Seas.

ACKNOWLEDGEMENTS

We are very grateful to the crew onboard the chartered vessels, the observers and the team leaders for their dedicated and pleasant cooperation in conducting the research. The hard work spent by K.A. Fagerheim and S. Hartvedt on validating and coding the survey data is much appreciated.

REFERENCES

Bøthun, G., Skaug, H.J., 2009. Description and performance of an automatic duplicate identification routine. SC/61/RMP3.

Bøthun, G., Skaug, H.J., Øien, N. 2009. Abundance of minke whales in the Northeast Atlantic based on survey data collected over the period 2002-2007. Paper SC/61/RMP 2.

International Whaling Commission. 2004. Report of the Scientific Committee. Annex D, Appendix 14. Report of the working group on North Atlantic minke whales RMP *Implementation Review*. *J. Cetacean Res. Manage. 6 (Suppl.):*171-183.

Langrock, R., D. L. Borchers and H. J. Skaug. 2013. "Markov-modulated nonhomogeneous Poisson processes for modeling detections in surveys of marine mammal abundance." Journal of the American Statistical Association **108**(503): 840-851.

Øien, N., Jørgensen, T., Øritsland, T. 1987. A stock assessment for Northeast Atlantic minke whales. Rep.int.Whal.Commn 37: 225-236.

Øien, N. 1995. Norwegian Independent Linetransect Survey 1995. *Interne notat, nr. 8 - 1995,* Havforskningsinstituttet, 58 pp (internal report).

Øien, N. 2016. Report of the Norwegian 2015 survey for minke whales in the Small Management Area EW Norwegian Sea and NASS-2015 extension survey in the Small Management Area CM Jan Mayen area. Paper SC/66b/RMP/06.

Øien, N., Bøthun, G. and Kleivane, L. 2009. Summary of available data on northeastern Atlantic minke whale surfacing rates. SC/61/RMP7.

Pike, D.G., Gunnlaugsson, Th., Mikkelsen, B., Halldorsson, S.D. Vikingsson, G.A. 2020. Estimates of the abundance of cetaceans in the Central North Atlantic based on he NASS Icelandic and Faroese shipboard surveys conducted in 2015. NAMMCO Scientific Publications11. https://doi.org/10.7557/34941.

Schweder, T., Skaug, H.J., Dimakos, X., Langaas, M., Øien, N. 1997. Abundance estimates for Northeastern Atlantic minke whales. Estimates for 1989 and 1995. Rep.int.Whal.Comm. 47:453-484.

Skaug, H.J., Øien, N., Schweder, T., Bøthun, G. 2004. Abundance of minke whales (*Balaenoptera acutorostrata*) in the Northeast Atlantic: variability in time and space. *Can.J.Fish.Aquat.Sci.* 61:871-886.

Skaug, H.J., Schweder, T., Laake, J. 2009. The effect of heterogeneity in line transect surveys with discrete cues. SC/61/O2.

Skaug, H.J., Solvang, H.K. 2015. A new variance estimator for Northeast Atlantic minke whales applied to survey data from 1996-2001. Paper SC/66a/RMP/5 Rev1 submitted to the IWC Scientific Committee 66a, San Diego, 22 May 2015.

Solvang, H.K., Skaug, H.J., Øien, N. 2015. Measurement error model for the Norwegian minke whale surveys 2008-2013. Paper SC/66a/RMP/7 submitted to the IWC Scientific Committee 66a, San Diego, 22 May 2015.

Solvang, H.K., Skaug, H.J., Øien, N. 2015. Abundance estimates of common minke whales in the Northeast Atlantic based on survey data collected over the period 2008-2013. Paper SC/66a/RMP/8 submitted to the IWC Scientific Committee 66a, San Diego, 22 May 2015.

Solvang, H.K., Skaug, H.J., Øien, N. 2021. Consideration of measurement errors for the Norwegian common minke whale (*Balaenoptera acutorostrata acutorostrata*) surveys. J. Cetacean Res. Manage. 22 (in press).

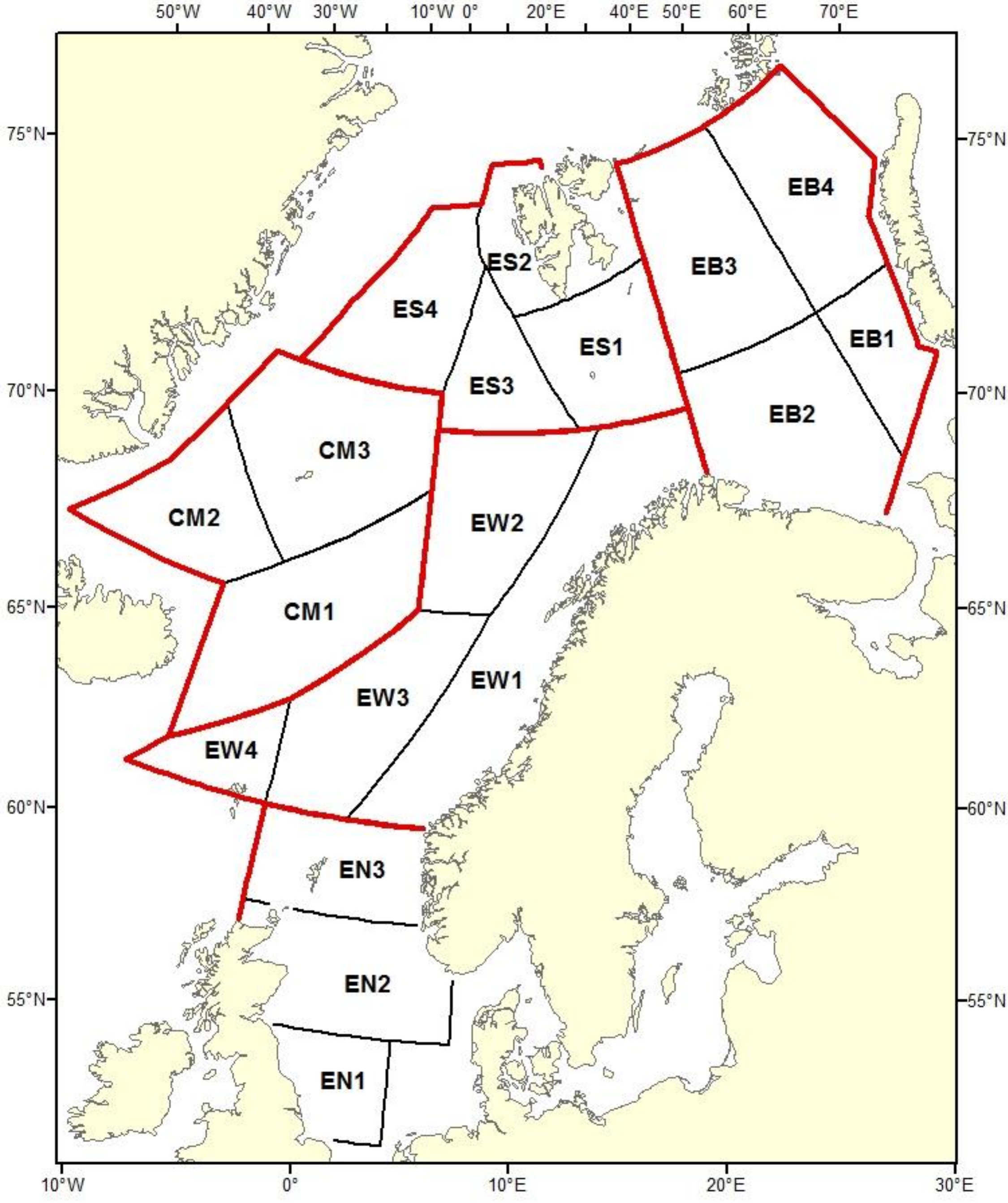


Figure 1. *The total survey area for the recent Norwegian sighting surveys. The Small Management Areas (SMA) EB, ES, EW, EN and CM are outlined in red and the applied stratum structures within the SMAs are shown with the codes used in this paper.*

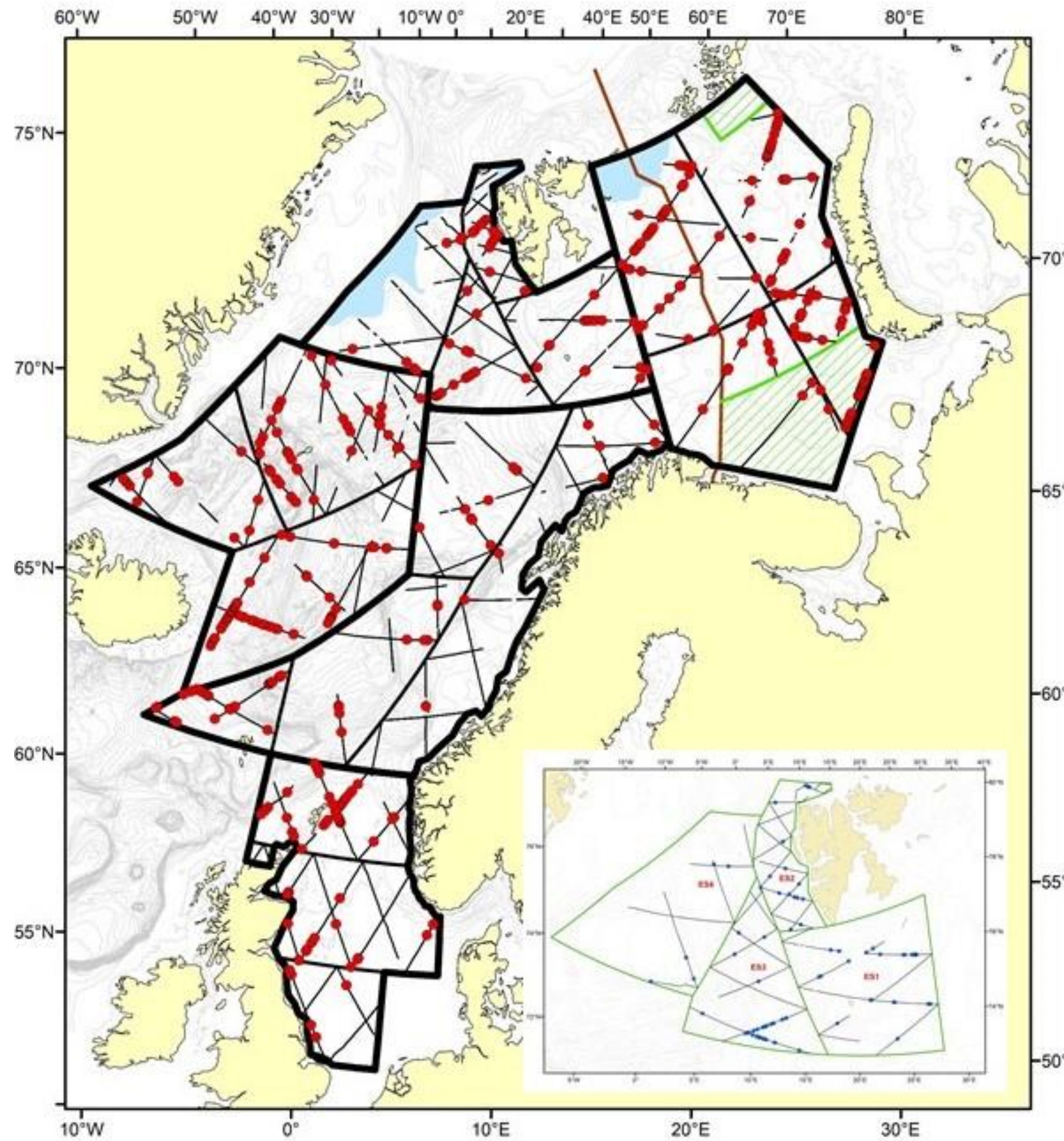


Figure 2. *The total survey area for the Norwegian surveys 2014-2019. The ES block off Svalbard was covered both in 2014 and 2019; for clarity the coverage in 2019 is given separately in the inserted map. The green hatched areas in the Barents Sea had access restrictions (see text), while the blue areas represent ice coverages. Transect lines covered in primary search mode (realised survey effort) are drawn together with primary minke whale sightings made from platform A.*

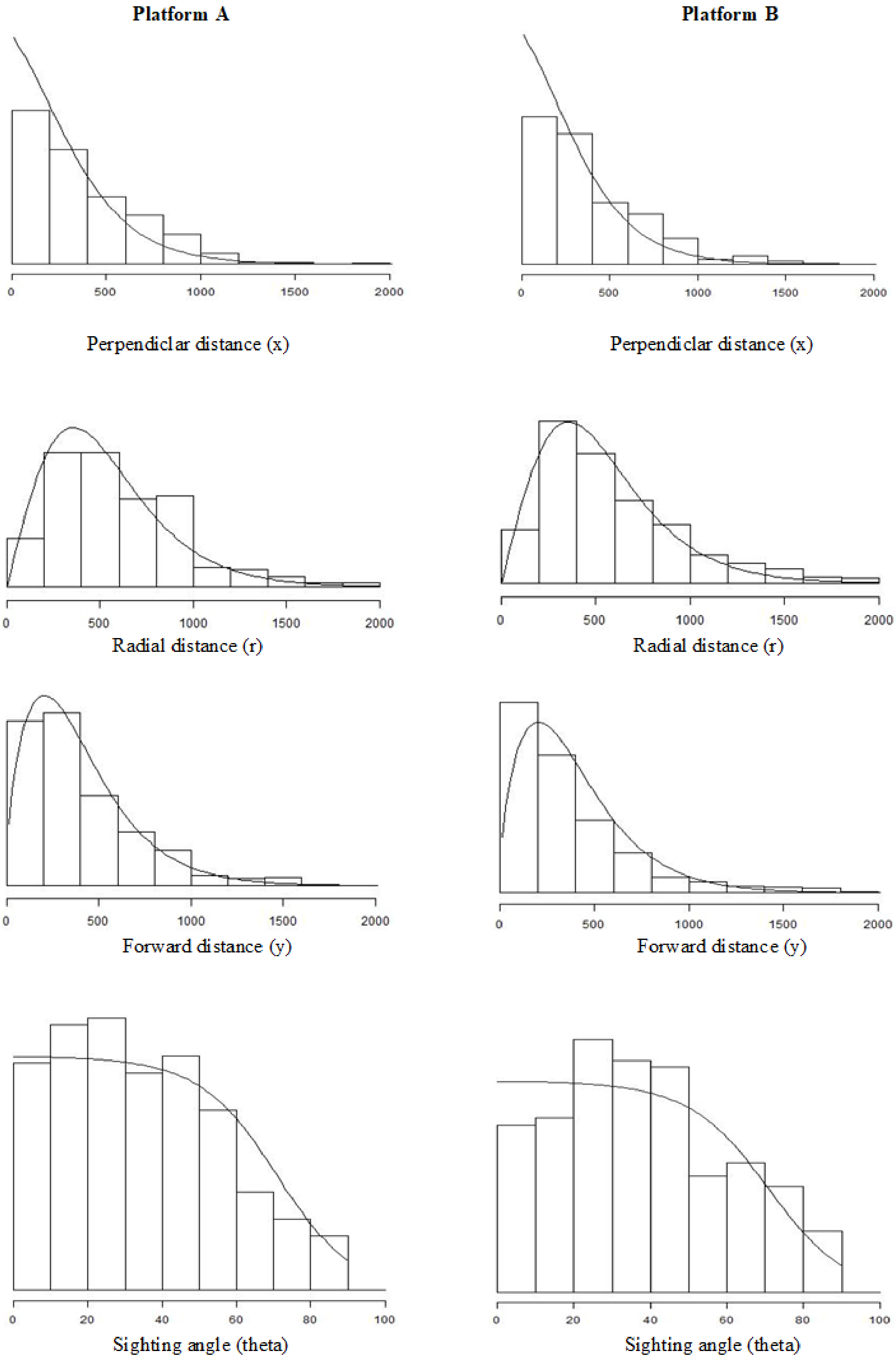
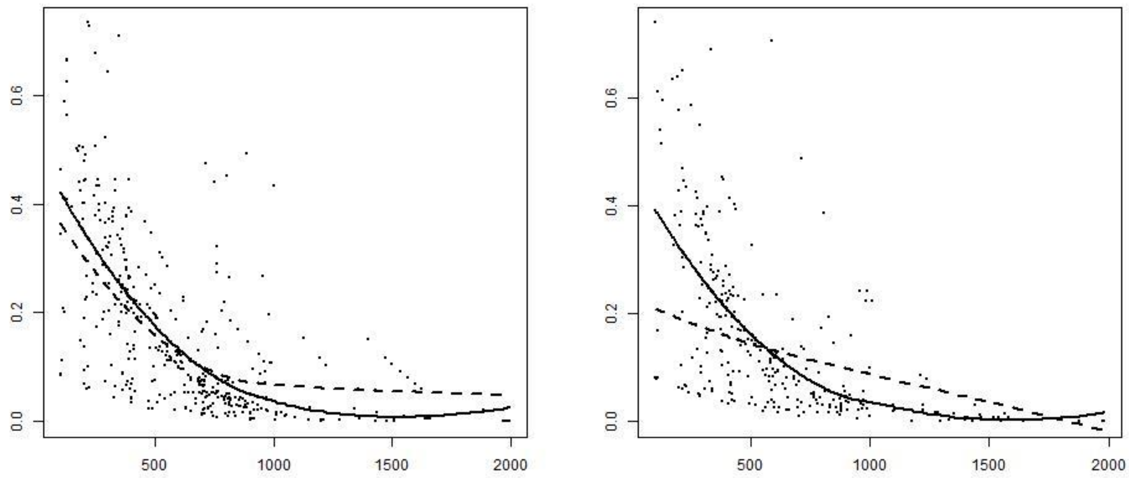


Figure 3. *Frequency distributions of collected distance data by observer platforms A and B together with fitted probability densities (solid lines). Panels are given for perpendicular distances, radial distances (truncated to [100m, 2000m]), forward distances and sighting angles.*

Platform A **Platform B**



Radial distance (r) Radial distance (r)

Figure 4. *Dots show estimated fitted success probabilities by radial distance for the Bernoulli trials, with associated loess smoother (solid curve). The dashed curve shows a loess smoother of the 0/1 response of the Bernoulli trials.*

Table 1. Covariates with description recorded hourly or more often during the surveys. The covariates have been aggregated in the analyses to the given levels as defined in the last column.

		Transformed (aggregated) covariates		
Covariate	**Description**	**Abbreviation**	**Levels**	**Definition**
Beaufort	5 categories	B	BI, BII, BIII	BI: [0-1], BII:[2], BIII: [3-4]
Weather	12 categories	W	good, bad	good: W01-W04, bad: W05-W12
Vessel	3 vessels	Ve	TRO, FTR, HMO	
Visibility	Numerical	Vi	High, Low	Low < 15,000 meters, High > 15,000 meters
Glare	4 categories	G	Glare, no glare	G0: no glare, G1: glare
Platform	Platform indicator	P	A, B	
Team	Individual observer codes	T	short, long	subjective classification

Table 2. Summary of survey results by survey block as arranged according to the RMP *Small Areas* (IWC, 2004). The information given is area of survey block, year in which the blocks were surveyed, realized transect length i.e. primary search effort (L), total number of sightings combined for the double platform (n_A+n_B), combined half strip widths w, and abundance estimates N with associated c.v. The options for combining the Medium Area E are:1, annual surveys 2014-2018; 2, annual surveys 2015-2019; 3, annual surveys 2014-2019 with ES(2014) and ES(2019) combined; 4, same as 3 with block EW4 included. Total is option 4 plus CM. All CVs for combined estimates include additional variance.

Small Area	Block	Year	Area (km^2)	L (km)	n_{A+B}	Hazard probability method w_{A+B}	N	CV		SMA Abundance	SMA CV
CM	CM1	2016	297 395	1 723	132	346.10	25 132.71	0.363	CM	37 020.11	0.261
	CM2	2016	177 962	1 289	28	476.26	2 939.85	0.584			
	CM3	2016	295 927	1 723	49	357.87	8 947.55	0.262			
EB	EB1	2017	107 105	1 027	101	294.00	14 252.39	0.275	EB	55 164.93	0.153
	EB2	2017	278 964	1 328	34	283.72	10 048.06	0.373			
	EB3	2017	232 370	2 054	89	315.68	12 513.11	0.276			
	EB4	2017	233 900	1 145	82	352.73	18 351.37	0.278			
EN	EN1	2018	95 674	1 135	19	300.33	2 109.37	0.324	EN	17 792.31	0.242
	EN2	2018	197 293	2 286	31	281.46	3 802.65	0.396			
	EN3	2018	160 657	1 595	92	307.49	11 880.29	0.331			
ES	ES1	2014	175 488	1 746	115	386.16	11 088.45	0.224	ES-2014	23 058.58	0.156
2014	ES2	2014	53 341	1 279	66	374.08	2 759.56	0.325			
	ES3	2014	118 763	1 559	107	407.30	7 402.40	0.243			
	ES4	2014	141 180	1 435	20	401.83	1 808.17	0.444			
ES	ES1	2019	164 150	1 852	72	298.25	8 471.27	0.217	ES-2019	15 693.21	0.190
2019	ES2	2019	56 044	1 716	34	318.02	1 369.47	0.329			
	ES3	2019	118 762	1 971	66	318.74	4 893.31	0.435			
	ES4	2019	151 261	1 314	6	287.30	959.15	0.470			
EW	EW1	2015	333 179	2 976	17	317.36	2346.55	0.292	EW1-3	12 594.64	0.252
	EW2	2015	218 942	1 509	21	286.07	4247.76	0.417			
	EW3	2015	228 404	1 046	24	335.56	6000.33	0.408			
	EW4	2018	84 625	916	60	277.46	8010.25	0.353			

Medium Area	Option	Year from	Year to		Abundance	CV
E	1	2014	2018		108 610.5	0.172
E	2	2015	2019		101 245.1	0.179
E	**3**	**2014**	**2019**		**104 692.1**	**0.172**
E	4	2014	2019	EW4	112 702.3	0.163
E+CM	TOTAL	2014	2019		149 722.4	0.152

Table 3. Comparison of different covariate models for the linear predictor η_r (radial distance). All possible combinations of the 7 covariates were tested and grouped into number of covariates fitted. The best model as judged by the AIC within each group is shown and the best overall model selected is shown in bold face. For illustration total (over all survey years and areas) abundances estimates without bias correction are shown in the last column.

Number of covariates	**Modelled**	**Modelling of covariates**			**Mean half strip width (SD)**		**Abundance**
included	**Covariates**	**# parameters**	**log-likelihood**	**AIC**	**Platform A**	**Platform B**	**total**
1	B	6	-7239.10	14490.21	203.70 (8.48)	203.70 (8.48)	175 826
2	B+Ve	8	-7217.63	14451.25	210.44 (8.48)	210.44 (8.48)	170 195
3	B+G+Ve	9	-7200.52	14419.05	214.79 (8.04)	214.79 (8.04)	166 748
4	**B+G+Ve+T**	**10**	**-7195.48**	**14410.95**	**215.21 (8.66)**	**216.45 (8.68)**	**165 945**
5	B+G+Ve+T+Vi	11	-7194.93	14411.85	217.40 (9.19)	218.51 (9.17)	164 327
6	B+G+Ve+T+Vi+W	12	-7194.64	14413.28	217.24 (9.22)	218.21 (9.21)	164 500
7	B+G+Ve+T+Vi+W+P	13	-7194.62	14415.24	218.16 (10.4)	217.71 (9.52)	164 342

Table 4. Estimated regression coefficients for the chosen hazard probability model.

	β_r	W,BI	W,BII	G,G0	Ve, HMO	Ve, FTR	T	β_theta	β_mu	λ_r	wA	wB
est	4.3155	1.18890	0.25075	0.68076	0.15536	-0.60792	0.35464	4.2659	1.2358	0.0045395	215.21	216.45
SD(est)	0.69898	0.479320	0.412800	0.340340	0.75024	0.111690	0.12620	0.024612	0.3137	0.00012548	8.6573	8.6813

Table 5. Abundance estimates with associated coefficients of variation (CV) by *Small Area* as currently defined by the International Whaling Commission (IWC, 2004). Combined total estimates for the E Medium Area and for the total survey area are also given – here the CVs include additional variance. Small Areas with an asterix (*) are the 'old' management areas defined by the first implementation (IWC, 1994). The summary estimate for the Eastern (E) Medium Area does not include the stratum EW4 so that a direct comparison can be made with the E estimates from previous survey cycles. The Total survey estimate for the period 2014-2019, on the other hand, includes also stratum EW4. The estimates from earlier surveys are given for comparison; 1989 and 1995 from Schweder et al. (1997), 1996-2001 from Skaug et al. (2004), 2002-2007 from Bøthun et al. (2009), and 2008-2013 from Solvang et al. (2015a).

	1988-1989		**1995**		**1996-2001**		**2002-2007**		**2008-2013**		**2014-2019**	
Small Area	**N**	**CV**	**N**	**CV**	**N**	**CV**	**N**	**CV**	**N**	**CV**	**N**	**CV**
ES*	13 370	0.192	25 969	0.112	18 174	0.25	19 409					
ES							19 377	0.33	27 390	0.16		
ES (2014)											**23 059**	**0.156**
ES (2019)											**15 693**	**0.190**
EB*	34 712	0.203	56 330	0.136	43 835	0.15	47 968					
EC*	2 602	0.249	2 462	0.228	584	0.26	3 457					
EB							28 625	0.26	34 125	0.23	**55 165**	**0.153**
EW							27 152	0.22	21 218	0.21	**12 595**	**0.252**
EN*	14 046	0.276	27 364	0.206	17 895	0.25	10 568					
EN							6 246	0.48	6 891	0.19	**17 792**	**0.242**
Eastern (E)	64 730	0.192	112 125	0.104	80 487	0.15	81 401	0.23	89 23	0.18	**104 692**	**0.172**
CM	2 650	0.484	6 174	0.357	26 718	0.14	26 739	0.39	10 991	0.26	**37 020**	**0.261**
TOTAL	67 380	0.19	118 299	0.103	107 205	0.13	108 140	0.23	100 615	0.17	**149 722**	**0.152**