MINKE AND FIN WHALES ALONG THE BARENTS SEA SHELF BREAK – DISTRIBUTION, HABITAT AND PREY SELECTION AND COMPETITION

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INTRODUCTION

Minke and fin whales are potential competitors as they have partly overlapping distributions and are believed to predominantly prey on pelagic fish (capelin and herring) and krill in the Barents Sea (e.g. Lindstrøm 2001). In 2000, 2001 and 2002 synoptic cruises were conducted along the Barents Sea shelf edge (Fig. 1). In this dynamic area, prey distribution and abundance varies considerably between years. We investigated minke and whale distributions relative to three physical habitat variables: depth, sea surface temperature (SST) and fronts recognised by steep SST gradients, and distributions of three groups of prey: plankton, 0-group fish and pelagic fish. To explore potential competitive interactions between minke and fin whales we furthermore investigated how these variables influenced the association between minke and fin whales

The following hypotheses were investigated:

•Do minke and fin whales demonstrate habitat and prey selection?

•Does minke and fin whale i) distribution and abundance, ii) habitat selection, or iii) prey selection vary between years?

•How does the association between minke and fin whales relate to habitat or prey distributions?

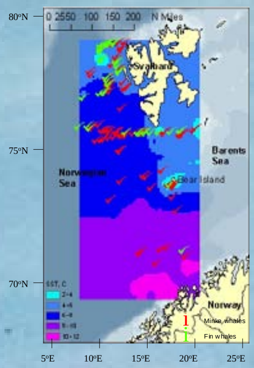

Figure 1. Map of study area and temperature field from 2000. Observations of minke and fin whales 2000-2002 are shown.

METHODS

Each year 2-week cruises along the Barents Sea shelf edge were conducted (Fig. 1-2). Prey distribution was recorded along predetermined transects using standard acoustic survey methods (Foote et al. 1991). Area back scattering coefficients (S_A) for each species group were averaged over 5 n mile cruise line segments indicated prey availability. Depth was measured along the cruise line and SST was measured in a grid with 35 n miles between sampling stations and interpolated. sdSST was calculated as the sd of the interpolated temperature field within 35 n miles.

Two observers on the bridge recorded all marine mammals along the cruise line. Number of minke whales observed, SST and sdSST were assigned to 5 n mile cruise line segments. Number of minke whales observed per cruise line segment was used as the response in a Poisson regression.

HABITAT AND PREY SELECTION

Number of minke and fin whale observations per cruise line segment was used as the response in a Poisson regressions to investigate habitat and prey selection.

RESULTS

Distributions of minke (106 observations) and fin (60 observations) whales differed little between years, although distribution and abundance of prey varied between years (Fig. 2). Fin whales were predominantly observed in northern areas in cold Arctic and mixed waters (Fig.1). Minke whales overlapped with fin whales, but were also observed further south in warmer Atlantic water masses (Fig. 1).

Associations between the cetaceans and habitat and prey varied between years (Fig. 2, Tab. 1 & 2). Minke whales were generally negatively associated with SST and positively associated with herring, while associations with fronts and capelin differed between years. Fin whales were generally associated with depth and capelin, while associations with SST, fronts, 0-group fish and herring differed between years.

Table 1. Estimates (and s.e.) of variables in selected model describing minke whale distributions in 2000, 2001 and 2002. Residual deviance = 446.95 (Null deviance = 528.19), residual df = 695.

Terms	Year-indep. effects	Year-dependent effects		
		2000	2001	2002
SST	-0.34 (0.07)			
Herring	0.16 (0.05)			
Year		0.55 (0.41)	-2.46 (0.97)	-1.10 (0.64)
Year*sdSST		0.17 (0.71)	-6.08 (1.75)	-3.78 (1.01)
Year*Capelin		0.48 (0.14)	0.19 (0.08)	-0.09 (0.08)

Table 2. Estimates (and s.e.) of variables in selected model describing fin whale distributions in 2000, 2001 and 2002. Residual deviance = 235.48 (Null deviance = 357.20), residual df = 689.

Terms	Year-indep. effects	Year-dependent effects		
		2000	2001	2002
Depth	1.24 (0.23)			
Capelin	0.26 (0.10)			
Year		-7.25 (1.95)	-5.57 (2.51)	-9.03 (1.89)
Year*SST		-0.32 (0.21)	-1.14 (0.28)	-0.24 (0.16)
Year*sdSST		2.91 (0.94)	-1.1 (1.72)	-0.08 (0.93)
Year*0-group fish		-0.21 (0.18)	0.77 (0.32)	0.24 (0.16)
Year*Herring		-0.78 (1.36)	0.28 (0.15)	-0.36 (0.13)

DISCUSSION AND CONCLUSIONS

No major changes in minke and fin whale distribution or abundance were evident during the three years, although prey distribution and abundance varied between years. The Poisson regression models showed that minke whales were associated with colder, shallower water masses and herring, while fin whales were generally associated with cold and deep waters and with capelin. Associations with other prey types differed between years in concordance with abundance; minke whales were associated with capelin in 2000 and 2001 when abundance of both herring and capelin was scarce, but not in 2002 when herring was abundant, fin whales were associated with herring in 2001 when herring was more abundant than capelin in the area occupied by fin whales. Fin whales were also associated with 0-group fish in 2001 when abundant within the fin whale area.

Our results support that minke and fin whales are opportunists, adapting their foraging behaviour to changes in the environment. Nevertheless, minke and fin whales also have different habitat and prey preferences, which may relax resource competition between the two species.

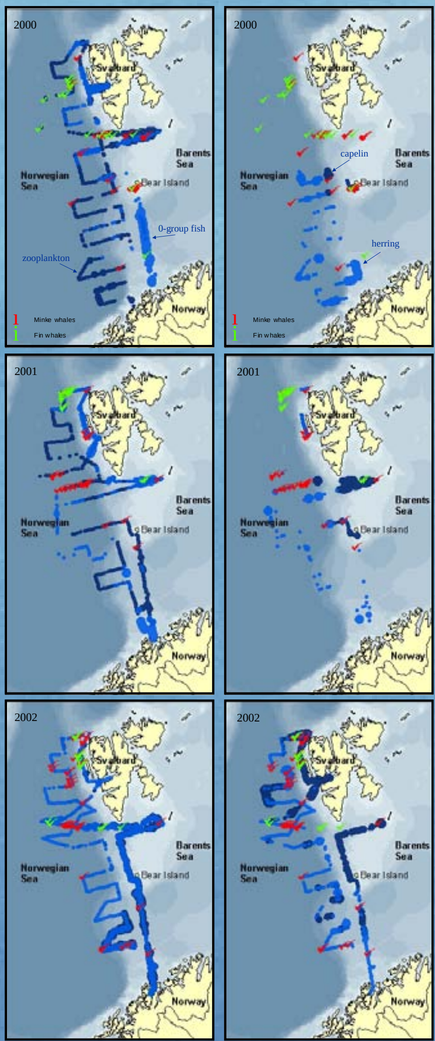

Figure 2. Distribution of plankton, 0-group fish (left), and capelin and herring (right) recorded along the Barents Sea shelf edge in 2000, 2001 and 2002, respectively. Observations of minke and fin whales are indicated.

ASSOCIATION BETWEEN PREDATORS

Index of association

$$I = \frac{P(M \mid F)}{P(M)} = \frac{P(F \mid M)}{P(F)} \quad \text{where}$$

$P(M)$ = Probability of minke whale present in transect leg

$P(F)$ = Probability of fin whale present in transect leg

$P(M \mid F)$ = Conditional probability of minke given fin present

Interpretation

- *I = 1* No association, i.e. fins and minkes are distributed independently of each other.
- *I < 1* Negative association (caused by differences in prey and habitat preferences)
- *I > 1* Positive association

Data

Only data from areas north of Bear Island were used, in order to ensure homogeneous densities of both of minke whales and fin whales. Only non-empty cruise line segments were used in the analysis, i.e. segments with zero observations of fin and minke whales were discarded.

Fitting the model – estimating the probabilities

- Mixed effect bivariate Poisson regression (counts of fins and minkes per segment)
- Random effects for fins and minkes correlated
- Explanatory variables (prey density and habitat type) included as fixed effects.
- Software: AD Model Builder (http://otter-rsch.com/admbre/admbre.html)
- Correction applied to the likelihood for the fact that empty segments were discarded.

RESULTS

Table 3 Fitted models where covariates were included one at the time (Intercept is the baseline model without any covariates)

Covariate	Log likelihood	Index I
Intercept	113.963	0.69
Herring (acoustics)	117.052	0.72
Log herring	117.634	0.76
Capelin (acoustics)	114.134	0.68
Log capelin	114.472	0.67
Plankton (acoustics)	116.634	0.65
Log plankton	113.986	0.68
Depth	117.859	0.69

In words:

•Negative association between minke and fin whales

•Inclusion of herring increases the association

•Inclusion of plankton decreases the association

DISCUSSION AND CONCLUSION

The strong negative association (*I < 1*) between fin whales and minke whales can be expected according to the Competitive Exclusion Principle (Gause, 1931), but the actual mechanism is not well understood. If not accounted for in the statistical analysis, the exclusion of empty segments could produce artificial strong negative association, but since a likelihood correction was applied, the explanation must be placed elsewhere. The remaining explanation is that minke whales and fin whales have different prey and habitat preferences.

The effect of including prey density as an explanatory variable was consistent with the single-predator analyses (see left part of the poster). In these, minke whales was found to be positively associated with herring, while fin whales were negatively associated with herring (in 2000 and 2002). As a confounder, herring would induce a negative association between minke whales and fin whales. Our findings were consistent with this hypothesis, in that inclusion of herring as an explanatory variable increased in the value of the index *I*, thereby reducing the negative association.

These results are preliminary. As seen from the likelihood values in Table 3, data do not contain much information to distinguish between the different models. Hence more data are needed.