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Agenda Item 4.1: **ASCOBANS Baltic Recovery Plan ("Jastarnia Plan") – Implementation**

The range of acoustic pingers in the Baltic and the North Sea

Submitted by: **Sweden**

ASCOBANS

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The range of acoustic pingers in the Baltic and the North Sea

Håkan Westerberg
National Board of Fisheries, Box 423, SE 40126 Göteborg, Sweden

John Spiesberger
Dep. Earth and Environmental Sci., 158 Hayden Hall, 240 S 33rd St., U Pennsylvania, PA 19104-6316, USA

Background

Acoustic pingers have been used as deterrents to avoid cetacean bycatch in fishing gear during a decade. Several trials have shown that pingers can reduce entanglement risk (Lien *et al*., 1992, Kraus *et al*., 1997, Larsen, 1999 Larsen *et al* 2001). A comprehensive review was made recently by the ICES Working Group on Marine Mammal Population Dynamics and Habitats (ICES CM 2002/ACE:02).

The ASCOBANS recovery plan for harbour porpoise in the Baltic (Jastarnia plan) recommends implementing pingers on a short term basis. This was opposed during the 2002 Advisory Committee meeting on the ground that the acoustic conditions in the Baltic is special and that the pinger signal may behave differently there compared to the in areas where pingers had been tested. It was decided that a simple modelling exercise should be conducted to study if pingers will function in the Baltic as they do elsewhere.

No analysis has been made of the sound propagation in any other area where pingers have been used. To make a modelling of the conditions in the Baltic meaningful a study also had to be done for the area in the northern North Sea, where the successful Danish pinger experiments have been made.

The modelling has been made with initial conditions representative for the cases where interaction is most probable – in the Baltic for the salmon drift net fishery and cod gillnets the whole year and in the North Sea bottom set gillnets in the autumn. The characteristics of the acoustic source was chosen to simulate the Aquatec Sub-Sea Ltd Aquamark 100^{TM}. In running the model the distance to where the pinger signal transmission loss was 56 dB was calculated in the vertical plane through the pinger. This loss is equal to the transmission loss at 300 m range in homogenous water, combining spherical spreading and sound absorption.

Input data

The Baltic Sea is a brackish, shallow sea with a strong salinity stratification. The upper 50-60 m are nearly isohaline. This surface layer is separated from the deep water by a smooth halocline at between 60-80 m depth, where the salinity increase is 3-4 psu and the increase in temperature is 2-3 deg. During the summer a variable seasonal thermocline develops in the upper 10-20 m, see Figure 1.

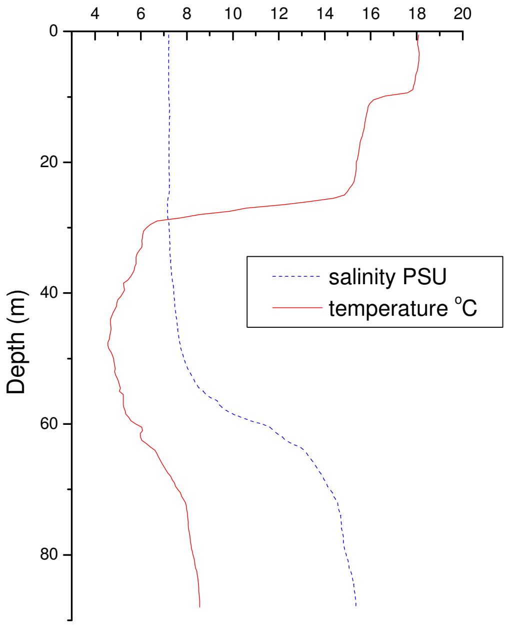


Figure 1. Stratification in the Bornholm deep in summer.

The southern North Sea is tidally well mixed, but to the north and east of the Dogger bank, at depths larger than 50 m, the water column is stratified. This is the region where the Danish experiments with pingers were made 1997. Compared to the Baltic Sea the salinity variations are small, but the seasonal thermocline is similar in strength in the two areas. A comprehensive review of the hydrographic conditions both for the Baltic and the North Sea can be found in Rodhe (1998).

Representative CTD casts were chosen to calculate the vertical sound velocity profile in the two areas. For the Baltic the Swedish hydrographic monitoring database was used to select a summer and a winter profile from the Gotland basin and a summer profile from the Bornholm basin. For the North sea the ICES archive was used and two autumn profiles were chosen from the Danish fishing area (Larsen 1999). The positions of the CTD stations is shown in Figure 2.

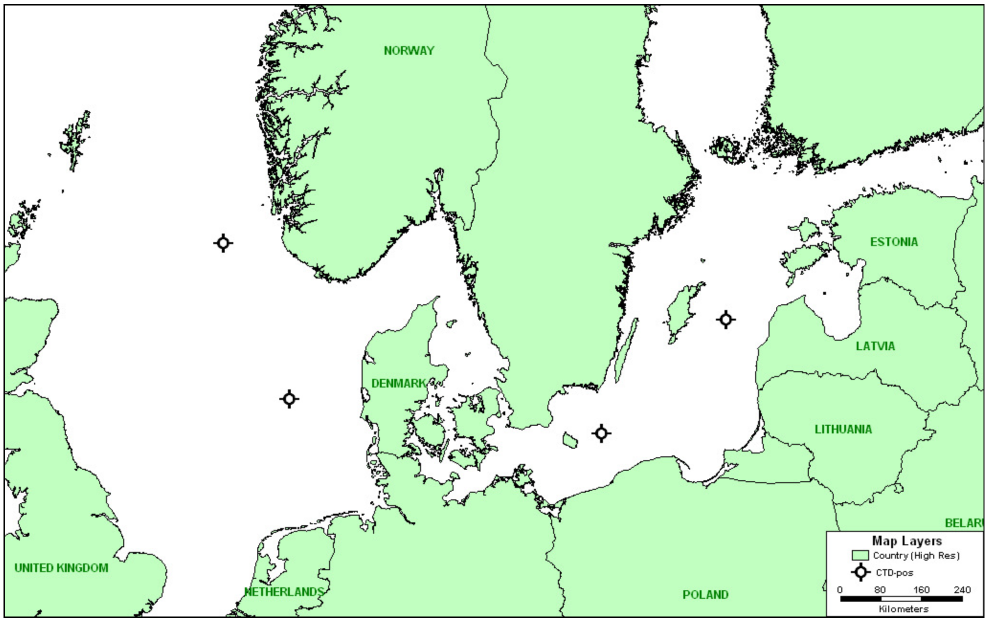


Figure 2. Positions of the hydrographic data used in the model.

The Swedish fishery with bottomset gillnets in the Baltic is mainly for cod and flatfish. The central and southern Baltic proper, where the conflict with harbour porpoise is most probable, is also the area with the highest fishing effort with gillnets. This is also where most of the driftnetting for salmon takes place. The depth distribution of the gillnetting is shown in Figure 3. The cod fishery is concentrated to the cold water below the thermocline and down into the halocline layer. Most of the flatfish fishery takes place above the thermocline.

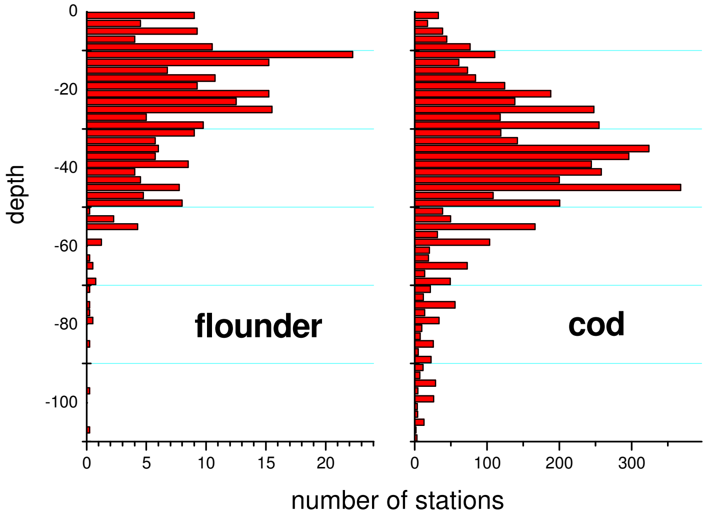


Figure 3. Depth distribution of bottomset gillnet stations in the Baltic fishery.

Methods

The transmission loss from a sound source with a frequency sweep from 20-160 kHz and a pulse length of 300 ms was computed in an x-z grid (where x is range and z is depth) using the ray-tracing program ZRAY (Spiesberger et al 1994). In each gridpoint the program scans through the different eigenray arrivals and uses the loudest to calculate the transmission loss for that point. The z values are spaced evenly in depth with a separation of from 2 to 6 m increasing with the bottom depth in the model. Horizontally the grid interval was 20 m out to 1000 m from the source. For each depth the distance in the x direction where the transmission loss equalled 56.14 dB was interpolated between gridpoints. This transmission loss is equal to that at 300 m distance for spherical sound propagation in a homogenous medium, and was chosen as a reference level, based on the observations that pingers in behaviour studies seems to give avoidance at approximately that distance.

The sound velocity profile was calculated using Del Grosso's algorithm (Del Grosso 1974) for the three cases in the Baltic and two in the North Sea. For each of those cases a range calculation was made with the sound source at 1 m depth and the full water depth of the profile, to simulate a pinger deployed at a drift net. The vertical grid spacing was 5 m for those calculations. To simulate deployment on a bottomset gillnet the bottom depth was varied from 10 to 60 m with 10 m intervals and the sound source was 2 m above the bottom for each such model run. The acoustic properties of the bottom sediments in the areas are not accurately known and a constant transmission loss of 20 dB was used for each bottom bounce, which means that the reflected rays have negligible effect on the loudness measured at the receivers.

In total 5 simulations were made for a pinger close to the surface and 28 simulations with the source 2 m above the bottom.

Results

The range calculations for the source depth 1 m below the surface is shown in Figure 4.

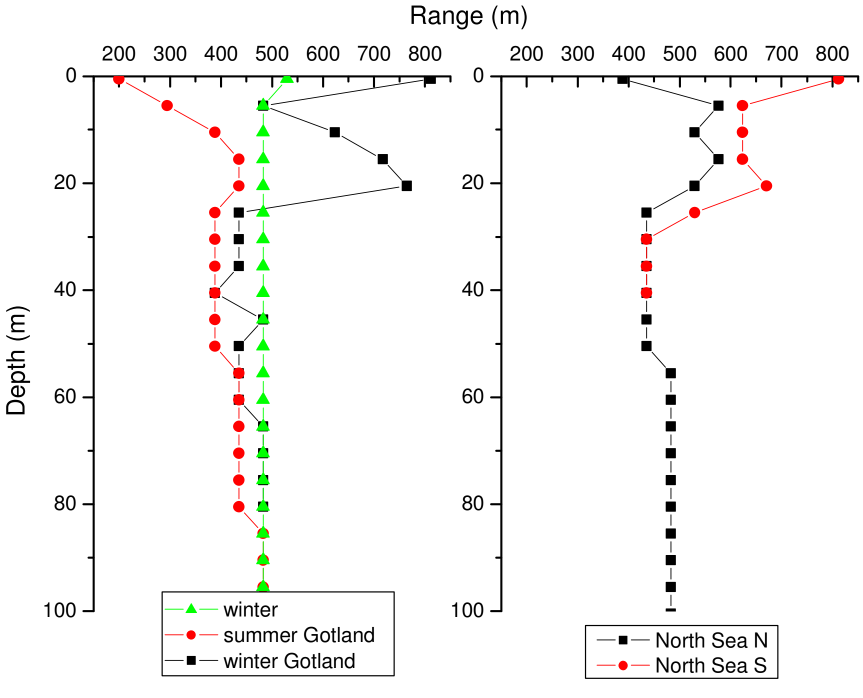
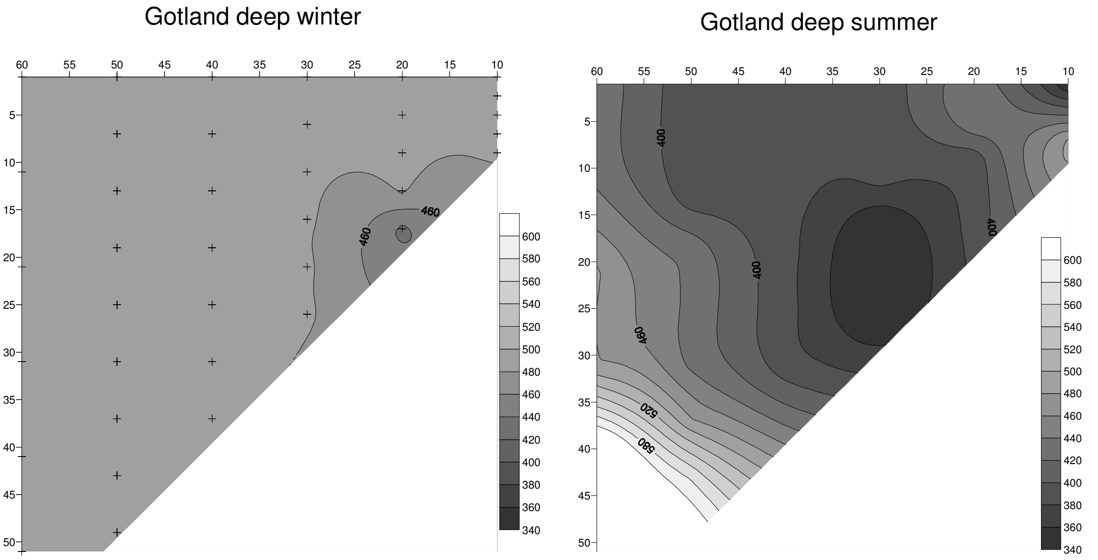


Figure 4. The range with a source at 1 m depth for a transmission loss of approximately 56 dB (equivalent to 300 m range with spherical propagation in homogenous water) as a function of receiver depth.

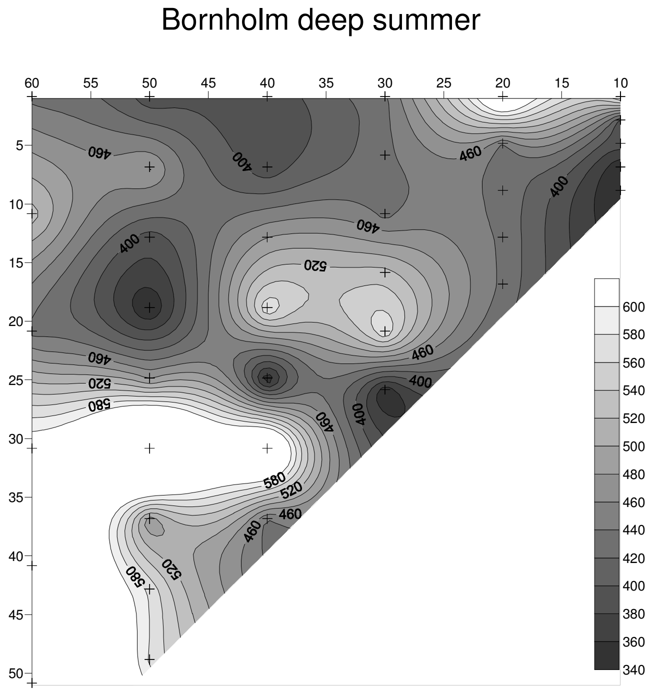
The results of the model runs with the source close to the bottom are presented in a contour plot for each sound velocity profile. These maps (Figures 5-7) show a schematic vertical section with a sloping bottom and with range contours in 25 m intervals. A point in the map shows the range with 56 dB transmission loss at the depth given by the y-co-ordinate, and with a source 2 m above the bottom at a bottom depth corresponding to the x-co-ordinate of the point.



Gotland deep winter

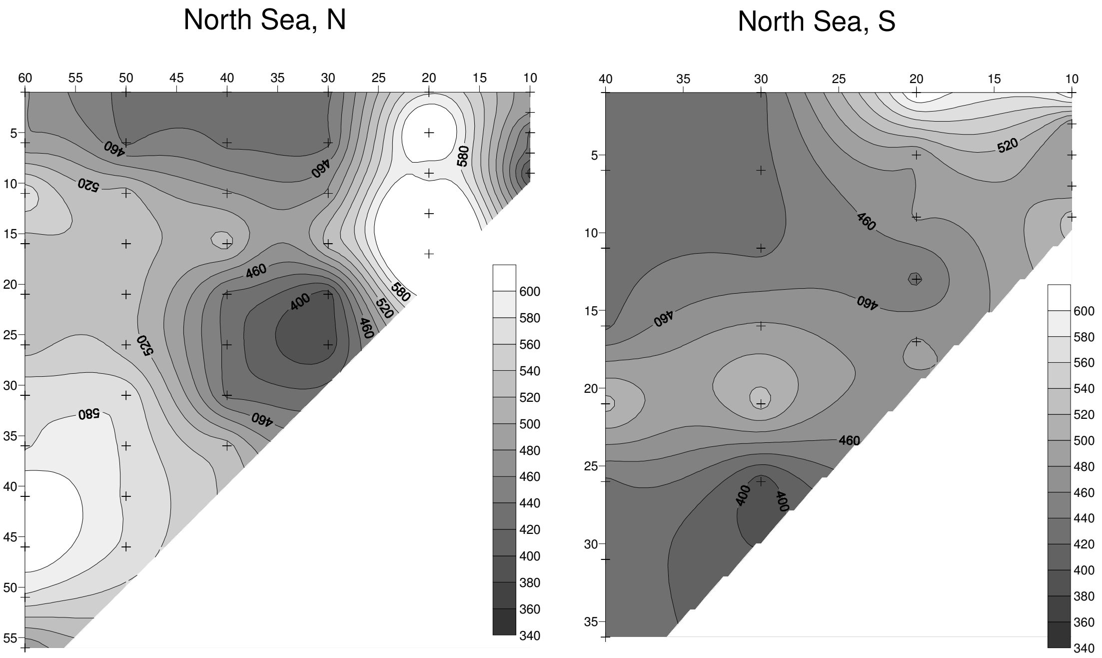
Gotland deep summer

Figure 5. Range in m of a pinger 2 m above the bottom in the Gotland deep in the Baltic. For interpretation of the map see text.



Bornholm deep summer

Figure 6. Same as Figure 5 for the Bornholm deep in the southern Baltic Sea.



North Sea, N

North Sea, S

Figure 7. Same as Figure 5 for two CTD-stations in the North Sea during autumn.

The minimum range calculated for the Baltic is 341 m and the maximum 811 m for a source close to the bottom. Table 1 shows the range variation for each sound velocity profile that was modelled.

Table 1. Maximum and minimum range calculated with pinger 2 m above the bottom.

Model area	Minimum	Maximum
Gotland deep winter	435	482
Gotland deep summer	341	670
Bornholm deep summer	341	881
North Sea north	388	623
North Sea south	388	717

Discussion

First it should be pointed out that the ranges calculated in the model are just comparable values that show equal transmission loss of signal strength, and that this signal strength is arbitrary and not the range where a harbour porpoise is known to react to the pinger. No measurements of the signal strength have been made in the behavioural studies of reaction distance.

The main conclusion of the study is that the perceived signal strength of a pinger can vary considerably, depending on the hydrographic conditions and the depths of both the pinger and the receiving whale. As seen in Table 1 a factor of two in reaction distance will be typical depending on those factors. There are no indication of severe restriction of the signal range however. In essentially all cases the actual transmission loss is smaller than in a case with homogenous medium and spherical sound distribution.

Comparing the Baltic and the North Sea there is no evident differences in how a pinger is likely to function acoustically. The conclusion is that the results regarding the effectiveness of pingers as by-catch mitigation can be transferred to the Baltic.

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