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AN INTERSHIP SONAR CALIBRATION EXPERIMENT IN THE NORWEGIAN SEA

by

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Abstract

When migrating in the Norwegian Sea in spring and summertime, the Norwegian spring spawning herring will be surveyed by vessels from four nations. Because the herring may occur in schools close to the surface, use of horizontal guided sonar may be an advantage for mapping the geographic distribution and estimation of abundance. To be able to compare the sonar recordings of schools obtained by different sonar systems on different vessels, an intership sonar calibration is nesessary. Such an experiment, which was the first of its kind, was conducted in the Norwegian Sea in June 1995. Vessels from the Faroe Islands, Iceland, Norway and Russia lined up with an intership distance of one nautical mile, and headed in the same direction at a speed of about 4 m s^{-1} over a total distance of 30 nautical miles. The number of schools recorded from 50 - 300 m to the side of the different vessels was quite similar, but the correlations between the number of schools recorded by the different vessels declined the smaller the sampling distance unit. The implication of the results for cooperative sonar surveys are discussed.

Introduction

When mapping the geographical distribution and migration routes of Norwegian spring spawning herring in the Norwegian Sea in the 50's and 60's, use of horizontal guided sonar was a central method (Devold, 1963; Jakobsson, 1963; Østvedt, 1965). At that time the sonar was used qualitatively to detect schools of herring, but trained sonar operators made a certain quantitative assessment by classifying the school size in categories ranging from "shit of flies", "corints", "grapes" to "elephant cakes". With the disappearance of the herring stock from the Norwegian Sea in the late 60's (Dragesund et al., 1980), the use of sonar became less important in fisheries investigations in the north-eastern Atlantic.

The herring in the Norwegian Sea is now again abundant, and the use of horizontal guided sonar is relevant for recording herring schools. The sonar method has been improved by the introduction of a high-resolution multibeam instrument (Misund et al., 1995) that is connected to a computerbased system for automatic detection and measurement of school size (Misund et al., 1994). Since 1993 this system has been used during annual surveys to map the distribution of herring in the Norwegian Sea (Misund et al., 1996).

Several countries have interests in the fish resources in the Norwegian Sea and therefore conduct annual fisheries investigations in the area. From 1995 actions were taken to conduct cooperative surveys between the Faroe Islands, Iceland, Norway and Russia on the herring stock in the Norwegian Sea in summertime (Anon, 1995; 1996). To be able to compare and make distribution charts on sonar recordings from different research vessels equipped with different sonars, it was decided to make an intership sonar calibration experiment in the Norwegian Sea in summer 1995 (Anon, 1995). The setup for the experiment was planned according to the standard procedure for intership calibration of echo integration systems (Foote et al., 1987). However, for horizontal guided sonars this was the first experiment of its kind.

Materials and Methods

To conduct the sonar calibration, four fisheries research vessels from different countries, R/V "Professor Marty" from Russia, R/V "Arni Fridriksson" from Iceland, R/V "Magnus Heinasson" from the Faroe Islands, and R/V "G.O. Sars" from Norway, gathered in position N 66° W 5° 30' at 14^{00} UTC on 17 June 1995. This position was chosen because of substantial recordings of herring in the area by R/V "Magnus Heinasson" about one week earlier. However, there were few schools in the area when the vessels arrived, and it was therefore decided that the vessels should sail side by side in a north-eastern direction to search for a more appropriate area. An eastern gale during the evening of 17 June also prevented a calibration excercise. The wind decreased to about 10 m s^{-1} during the night. On the morning of 18 June the vessels approached an area with purse seine fishing in position N 67° W 4° 30'. It was decided to start the sonar calibration in position N 67° 05' W 4° 30' (Fig. 1) at about 06^{45} UTC, and sail north at a speed of about 4.5 m s^{-1} (8 knots). The vessels lined up in the following order: R/V "G.O. Sars", R/V "Professor Marty", R/V "Arni Fridriksson" and R/V "Magnus Heinasson". To avoid sailing in the propeller wakes of the vessels in front, the vessels sailed one nautical mile apart and slightly to the side of each other (Fig. 2). R/V "Professor Marty" had R/V "G.O. Sars" at 10° bearing starboard, R/V "Arni Fridriksson" had R/V "Professor Marty" at 10° bearing port, and R/V "Magnus Heinasson" had R/V "Arni Fridriksson" at 10° bearing starboard. The intership calibration excercise ended in position N 67° 35' W 4° 30' at about 11^{00} UTC.

On all vessels the sonars were directed 90° port and tilted to -10°. A sonar with 10° vertical beam width will then cover at depth of 4 m to 14 m at 50 m range and 25 m to 80 m at 300 m range. Onboard R/V "Professor Marty", R/V "Arni Fridriksson" and R/V "Magnus Heinasson" trained operators counted the number of schools detected within 50 m to 300 m to the side of the respective vessels. Onboard R/V "G.O. Sars" the number of detected schools was counted both manually and automatically by the computerbased sonar system (Misund et al., 1994). Onboard the Faroes, Norwegian and Russian vessel, the number of schools was counted for each nautical mile, while on the Icelandic vessel the number of schools counted was summed for intervals of five nautical miles.

The four vessels were equipped with different sonar systems (Table 1). To achieve high resolution and thereby improve the probability for manual school detection, the systems were operated with a range setting of 300 m or the nearest range setting above 300 m. The 300 m limit was also chosen because sound absorption, that increase drastically for higher frequencies, reduces the detection probability of small schools beyond that range by the 95 kHz Simrad SA950 sonar onboard R/V "G.O. Sars". The sonars were operated with settings that were optimal for school recording at the sea conditions present during the calibration transect. The school detection system connected to the Simrad SA950 sonar was set with a detection threshold at colour value 15, a lengthwise school extent of 5 m, and a minimum number of four detection pings.

The calibration transect appeared to be in the most actual area for purse seine fishing by nowegian and icelandic vessels. Three Norwegian vessels with herring catches alongside were passed during the transect, and an Icelandic flotilia of about 20 vessels heading east crossed the transect at about N 67° 15' to N 67° 20'. Therefore, the calibration transect was probably in the best possible location for recording of herring schools in the area at the respective date.

Results

During the 30 nautical mile-long calibration transect, 68 schools were counted manually onboard both the Faroes and Norwegian vessels. Onboard the Russian and Icelandic vessels 49 and 51 schools were counted, respectively. The school detection system connected to the Simrad SA950 sonar onboard R/V "G.O. Sars" recorded 39 schools only. This indicate that the detection criterias on the computerbased detection system onboard R/V "G.O. Sars" were set to strict to record 29 small schools also clearly present on the paper record of the sonar.

When comparing the recordings on one nautical mile basis, there were substantial differences among the Faroes, Norwegian and Russian vessels (Fig. 3), and there was no significant correlations between the number of schools recorded by the Norwegian and the Russian or the Faroes vessels (Table 2). However, there was a significant correlation between the number of schools detected by the Russian and Faroes vessels. When comparing the recordings on five nautical mile basis, there were still substantial differences in the number of schools recorded by the different vessels (Fig. 4) and no significant correlation in the number of schools recorded by the different vessels (Table 3). However, the modal pattern in the number of schools recorded between mile 10 and 25 seems to be present in the recordings of all vessels.

During the calibration transect, three schools only were recorded by the 38 kHz Simrad EK500 echo sounder onboard R/V "G.O. Sars", and similarly few schools were recorded by the echo sounders of the other vessels also. Because of these few recordings, comparisons between the sonar and echo sounder recordings within and among the vessels were impossible.

Discussion

If properly conducted in an adequate area, intership calibration of echo integration systems usually give strong intership regressions of the area backscattering coefficients obtained over a distance of 30 nautical miles (MacLennan and Simmonds, 1992; Røttingen, 1978). This was not the case with the number of schools recorded by the four vessels participating in our sonar calibration experiment. There were both a varying number of schools detected by the different vessels and a lack of intership correlation at small sampling distance unit. However, the intership correlations improved when using five nautical miles as sampling distance unit, but still none of the correlations was significant.

However, a direct comparison between our sonar calibration experiment and regular echo integration system calibration experiments is not relevant. This is because the fish distribution recorded during the sonar calibration experiment is fundamentally different from that normally encountered during intership calibration of echo integration systems. In our experiment the herring were distributed in distinct schools of varying size in the upper water column. The schools were quite scattered in the area, and recordings of 50 schools over a distance of 30 nautical miles indicate an average distance of about 1100 m between the schools. However, the schools were not even distributed, but occured in small groups or clusters. When conducting regular intership calibration of echo integration systems, areas with fish distributed in continuous pelagic or bottom layers are normally chosen. In fact, a regular intership echo integration calibration experiment would have been impossible in the actual area because of the scattered distribution of fish schools. This is illustrated by just three schools being detected within the narrow beam (7.1° between the -3dB points) of the vertically directed echo sounder of R/V "G.O. Sars" over the whole calibration transect.

The scattered distribution of the herring schools indicates that intership correlations of the number of schools detected over small sampling distance units have little value. This is evident from the lack of intership correlation of the number of schools detected per nautical mile. The intership correlations improve when five nautical miles was choosen as sampling distance unit. A calibration transect of thirty nautical miles gives six data points only when using number of schools per five nautical miles, none of the six intership correlations was significant. A longer calibration transect that produced more five nautical mile data points would therefore have been an advantage.

The tendency to improved intership correlation when applying longer sampling distance units indicate that the total number of schools detected over the whole calibration transect for each vessel could be used to develop vessel-dependant scaling factors. For each vessel this can be done by dividing the number of schools detected during the calibration transect by the average number of schools detected by the four vessels during the calibration transect. For calculating relative indexes of herring abundance in the Norwegian Sea based on recordings with different vessels with different sonar equipment, the number of schools detected by the different vessels must be scaled by such vessel specific scaling factors.

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Table 1. Acoustic characteristics of the sonar systems used during the intership sonar calibration experiment in the Norwegian Sea, June 1995.

Vessel	Sonar	Frequency (kHz)	Horizontal beam (-3 dB)	Vertical beam (-3 dB)	Pulse length (ms)	Display
"Professor Marty"	Sargan	120	14°	14°	3	Paper
"Arni Fridriksson"	Kaijo Denkij	24	360° sector scan, 12° on 15 reception beams 12	12°	15	CRT
"Magnus Heinasson"	Simrad SU	15	14°	11°	6	Paper
"G. O.Sars"	Simrad SA950	95	45° sector scan, 1.7° on 33 reception beams	10°	0.3	CRT and Paper

Table 2. Correlation coeffisients (r) for the number of schools recorded per nautical distance sailed during the calibration transect (ns: $p > 0.05$, s: $p < 0.05$, n: number of observations).

	One nautical mile recordings			Five nautical mile recordings		
	r	p	n	r	p	n
"G. O. Sars" vs. "Professor Marty"	-0.20	ns	30	0.28	ns	6
"G. O. Sars" vs. "Arni Fridriksson"				0.65	ns	6
"G. O. Sars" vs. "Magnus Heinasson"	0.28	ns	30	0.70	ns	6
"Professor Marty" vs. "Arni Fridriksson"				-0.26	ns	6
"Professor Marty" vs. "Magnus Heinasson"	0.37	s	30	0.47	ns	6
"Arni Fridriksson" vs. "Magnus Heinasson"				0.67	ns	6

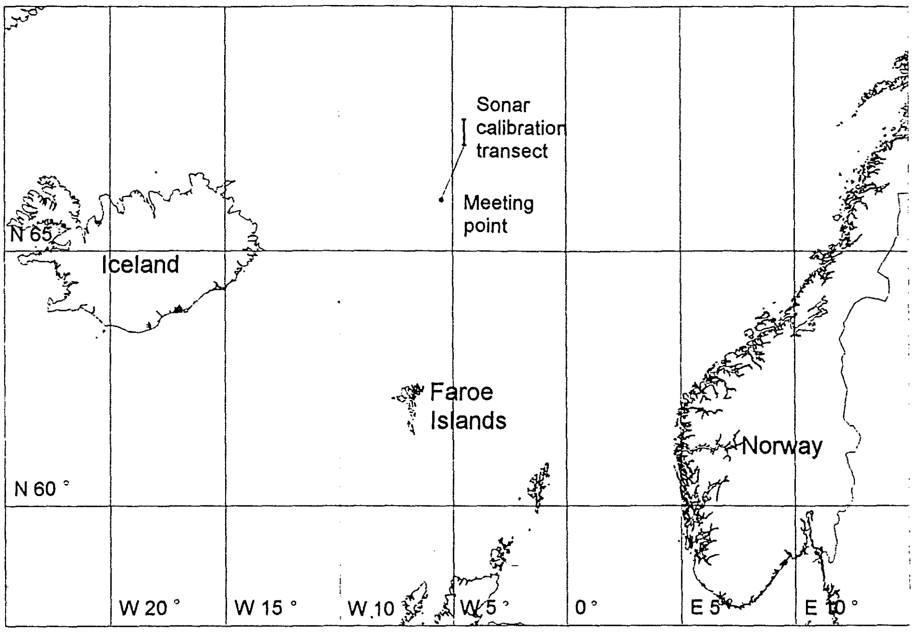
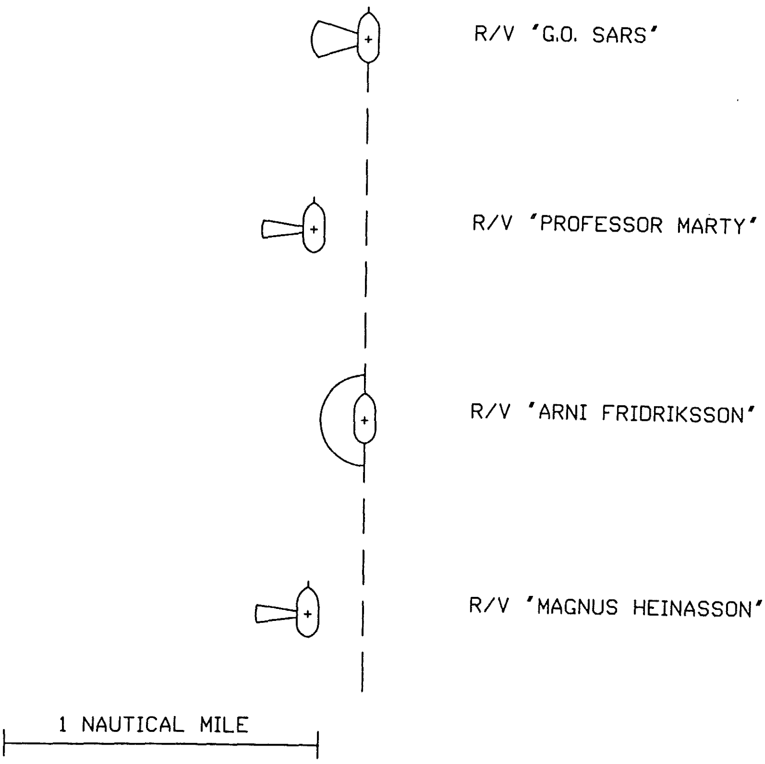


Figure 1. Position of sonar calibration experiment.



Figur 2. Sailing order of the research vessels during the sonar calibration experiment.

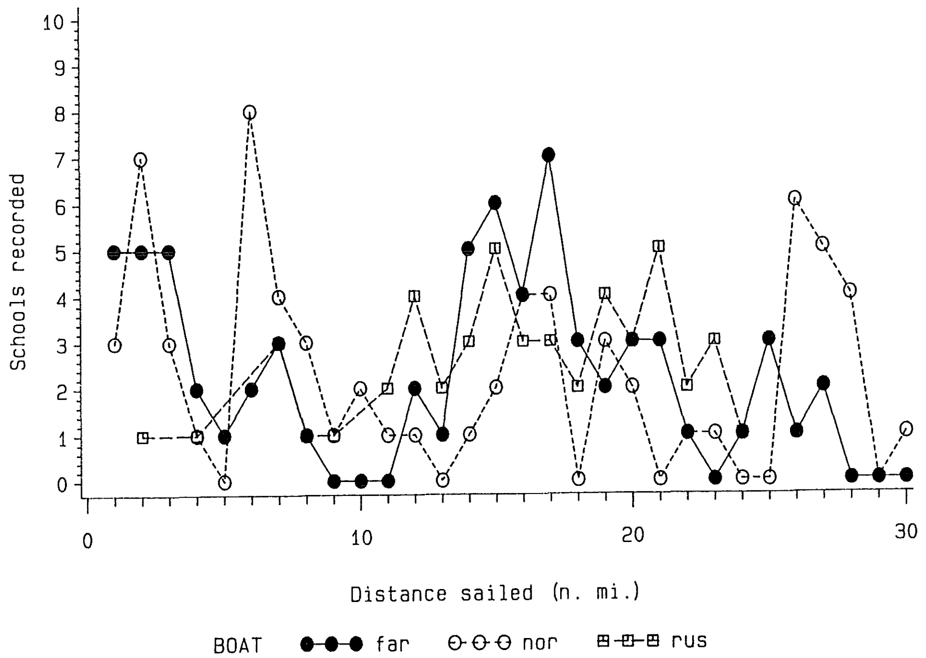


Figure 3. Number of schools recorded per one nautical mile of the sonar calibration transect by the Faroes (far), Norwegian (nor) and Russian (rus) vessel.

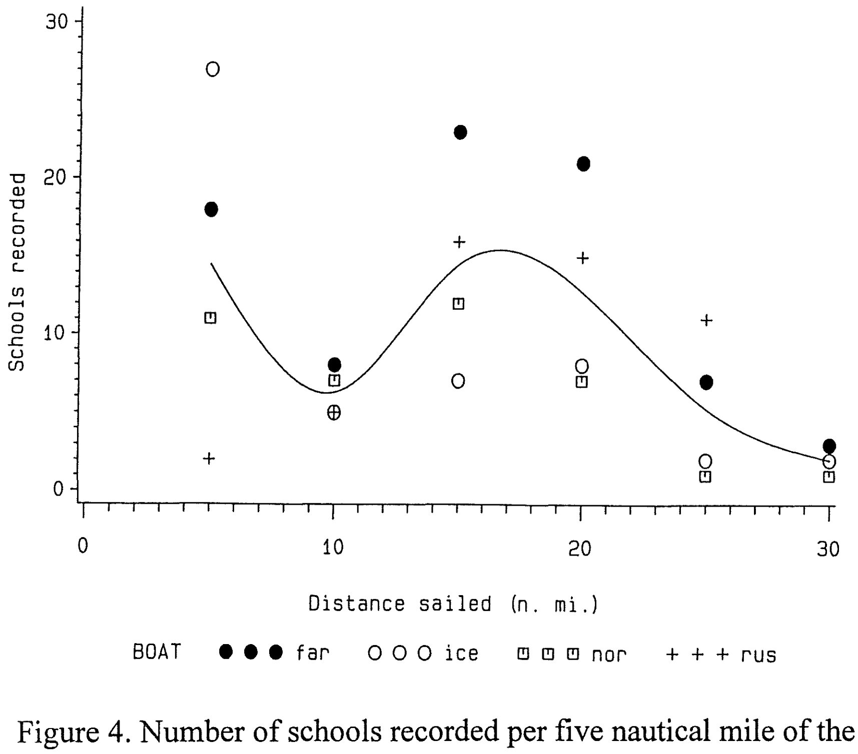


Figure 4. Number of schools recorded per five nautical mile of the sonar calibration transect by the Faroes (far), Icelandic (ice), Norwegian (nor) and Russian (rus) vessel.