PRELIMINARY ACOUSTIC RESEARCH OF DIVING ARCTIC BIRDS

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This paper aims to introduce the preliminary results of acoustic studies of the diving strategy of Arctic birds. It presents the inverted echosounding and noise measurements performed by the Autonomous Hydroacoustic System (AHS) in Isfjorden (Spitsbergen). Both the echograms and the noise record have been analysed as far as the birds' diving is concerned.

INTRODUCTION

The research has been conducted as a part of the international ALBERT project (Arctic Life: Bridging Ecosystem function using Remote Technologies). The main objective of the project is to estimate the impact of climate warming on Arctic zooplankton communities (*Calanus*) and Arctic birds**,** little auks (*Alle alle*), and their physical environment. The little auk is considered a keystone species in the Arctic ecosystems, with a total population estimated at 30 million pairs. The warming Arctic climate causes changes in the little auk's diet – the Arctic species of zooplankton are replaced by the Atlantic ones. In this way the condition of the little auk is a marker of a changing climate. Little auks breeding in Spitsbergen feed mainly on the large species of zooplankton – copepods. The adults of Arctic *Calanus glacialis* and *Calanus hyperboreus* are considerably larger and contain, respectively, approximately 10 and 25 times more energy (lipids), than the Atlantic *Calanus finmarchicus*. This high lipid accumulated by calanoid copepods is an essential energy source exploited by large stocks of fish, sea birds and marine mammals, enabling them to sustain over-wintering populations.

The acoustic part of the ALBERT project focuses on the investigation of the diving strategy of little auks. The paper presents and analyses an 11-day series of measurements conducted by the Autonomous Hydroacoustic System (AHS) deployed at the depth of 60m in the Spitsbergen fjord close to the bird colony. The acoustic system is a buoy with an up-looking echosounder working at the frequency of 130 kHz and equipped with two external omnidirectional hydrophones. The echosounder can detect the aggregations of zooplankton and also the entrainment depth of gas bubbles produced by birds diving for their prey. The hydrophones record the ambient sea noise and its directivity in a broad frequency band from a few hundred Hz to 35 kHz. AHS dataset, both the echogram and the noise record, has been analysed for the events of the birds' diving.

1. EXPERIMENTAL SETUP AND OPERATION

The experiment took place in Isfjorden in the vicinity of Longyearbyen, capital of Svalbard (φ =78°14'23''N, λ =15°17'43''E). This particular place has been chosen, first of all, because of the neighbourhood of the large colony of breeding little auks' and also for logistic reasons, because of the easy access from the operational centre at the University of Svalbard. The disadvantage of this location is ship traffic, which causes a harmful noise background. In the middle of the polar day, thousands of tourists come to Svalbard every day on different vessels to see the fjords. There is also a considerable number of research vessels. AHS was anchored at the depth of 60m, about 1 mile from the shore. The operation started at 13:00 on 17 July and ended at 10:50 on 28 July 2007.

The Autonomous Hydroacoustic System (AHS) comprises the upward looking echosounder, two omnidirectional hydrophones and steering and recording electronics. The whole system consists of a pressure container, a pressure sensor, a computer, hydrophones attached to the container and an upwards-pointing hydroacoustic transducer mounted on top of the container, with an acoustic release and anchor attached to the bottom of the container. The echosounder works at 130 kHz. Its receiver circuitry consists of an amplifier and an envelope detector. The time varied gain (TVG) of the system can be implemented as any function in a dynamic range of 80 dB. The preamplifier is built in the hydrophone output. It is equipped with high-pass filters to avoid saturation from low-frequency ship sound and to reduce the influence of the surface wave motion and cable vibrations. Also aliasing from high frequency noise portion is reduced due to low-pass filters. The hydrophones are separated horizontally by 60cm. Such a distance**,** being a quarter wavelength at the frequency 600 Hz, has been selected in order to make use of the directivity algorithm. The whole system has a positive buoyancy due to 15 spherical floats attached symmetrically to the container.

The computer controls the external pressure, echosounder triggering, power supply relays, and data logging rates. It regulates the system operation in repeated 10-minute cycles. Each full cycle of registration includes:

- 2-minute period of echosounding - 128 transmissions, pulse duration of τ =0.3 ms gives a spatial pulse length of 0.22 m, the pulse repetition time of t_r =500 ms;
- 6 minutes of two hydrophones registration;
- 2-minute period of one hydrophone registration.

2. DATA PROCESSING AND ANALYSIS

The sampling of the echo signal envelope is performed by a 12-bit analogue digital converter. The sampling rate of 11 kHz ensures a depth resolution of 0.068 m. The voltage data acquired were converted into the volume backscattering strength *SV* by concerning geometrical beam spreading and absorption in sea water as well as technical parameters and calibration constant giving the *SV* matrix [2]:

$$SV(z,t) \equiv SV(z_j, t_k) \tag{1}$$

where:

$$z_j = j\,\Delta z \qquad \Delta z = \frac{c}{2\ f_{sample}} \cong 0.068m$$

$$t_k = k\,\Delta t \qquad \Delta t = 10_{\min utes}$$

This provides for the formation of vertical profiles of *SV* over time in any scale, from minutes to days.

The two-channel 16-bit ADC samples noise signals with a frequency 32 kHz in the case of two hydrophones, or 85 kHz when only one hydrophone is used. Afterwards, the digital filters with central frequencies logarithmically spaced in the frequency range from 0.4 –31.5 kHz, ensuring nonoverlapping coverage in the whole registered frequency band, were used to receive Noise Spectrum Level.

3. RESULTS

A brief inspection of the echograms revealed many cases of birds' presence in the water. The exemplary result is presented in Fig.1, where the trace of an object diving to the depth of 10m is visible. Its return to the surface lasts over 1 minute. It is interesting that while the birds move downwards, with folded wings, in the most streamlined position, they are invisible. Just after they reach the desired depth, the entrapped gas bubbles are released and start their way back to the sea surface in the usual chaotic way, producing strange sounds and being a distinct target for the echosounder. The depth reached by the diving birds detected by the echosounder during our experiment varies between 4m and over 25m.

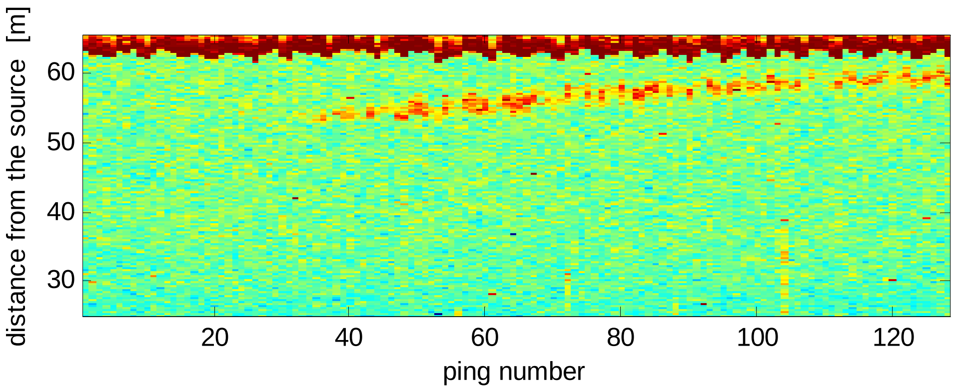

Fig.1 Echogram

Unfortunately, we do not have the simultaneous records of echo and noise because they were recorded successively. We can only expect that the birds' diving observed in the active mode will have its reflection in the following passive cycle of measurement. But it is not always the case. The illustration of the noise record is shown in Fig.2. The different curves describe different frequency bands (their central values in kHz are marked in the legend). Both the bird record (left peak) and the ship noise (broad right peak) can be observed very easily. The noise signals are very often disrupted by the ships passing in the vicinity of the anchored buoy. Special methods have been used to get rid of this kind of interference [1]. Further improving steps are currently being tested.

There is a necessity for constructing some criterion for the automatic detection of the bird events in the noise file. We hope to find some hint in the noise spectrum, because there is a characteristic difference in its shape depending on the presence or absence of birds in water. It is shown in Fig.3.

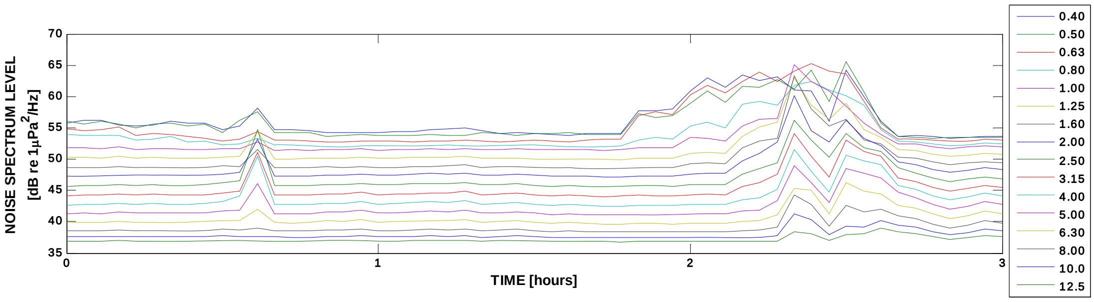

Fig.2 3-hour noise record for 16 frequency bands

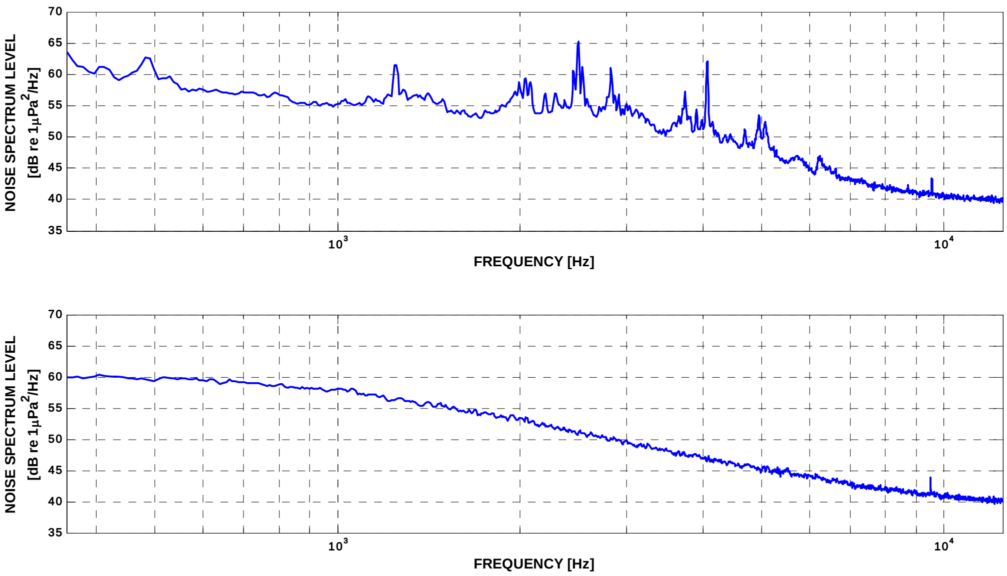

Fig.3 Comparison of Noise Spectrum Levels for the record with bird (upper part) and without (lower part)

4. SUMMARY

This paper has presented the preliminary results of noise and echosounder research on the diving Arctic birds. The results are far from excellent but quite promising. There are no concurrent ornithological observations, so we are not able to verify the acoustically recorded events. Further research is planned as a part of the International Polar Year and Polish-Norwegian collaboration.

ACKNOWLEDGEMENT

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