# STUDY OF SWIMBLADDER MORPHOMETRY OF BALTIC HERRING AND SPRAT (DEVELOPMENT OF MEASUREMENT METHODOLOGY)

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*Effective management of Baltic clupeids, which are valuable commercially and ecologically, requires the biomass control. The acoustical techniques are recognized as effective in fish stock assessment. The study of Baltic herring and sprat individual backscattering characteristics is required for the accurate biomass estimation using acoustical techniques. The previous measurements demonstrated significant dependence of the backscattering properties of Baltic clupeids on their geographical location. For southern Baltic Sea the properties are not recognized sufficiently yet. Accounting for that fish swimbladder morphometry effectively impacts on the backscattering, it is important to study the morphometry of southern Baltic herring and sprat. It motivated the paper study. The paper is addressed to the development of the methodology of the analysis of the accurate shape of the swimbladder. The way of the fish catch, transport and storage, the X-ray irradiation and the X-ray image analysis was developed.*

## INTRODUCTION

Herring and sprat, the economically valuable species, are the key elements of the pelagic ecosystem of the Baltic Sea (Raid and Kaljuste, 2005). To manage the resources of these two species reasonably, the biomass monitoring is required. The acoustical method is recognized as effective because of the relatively quick and not invasive way of data collection from large areas. The dependence of the fish backscattering characteristics, target strength (*TS*) on its total length (*L*): *TS(L)* (MacLennan and Simmonds, 1992), is critical in acoustical assessment. This relationship is required for the conversion of the collected acoustical data (echo energy) into the biological data (fish abundance or biomass). The dependence of *TS(L)* for Baltic clupeids was investigated conducting measurements (Rudstam et al., 1988, 1999; ICES, 2000; Didrikas and Hansson, 2004; Didrikas, 2005; Peltonen and Balk, 2005; Kasatkina, 2009) and numerical modelling (Gorska, 2007; Fässler et al., 2008; Fässler and Gorska, 2009). However, the measurements did not reply to the basic question – which dependence *TS(L)* of Baltic herring is reasonable to use in the acoustical abundance estimation? It is because the relationships of *TS(L)* differ (up to 8 dB) for different seasons, distant parts of the Baltic Sea and developed methods of collection and processing of the acoustical and biological data. The difference has not been explained yet and the further research is required. Therefore, study of the *TS(L)* relationship for the southern Baltic Sea (ICES Subdivisions 24, 25, 26; Fig. 1) is important. According to the international ICES convention Poland is responsible for fish stock estimation in these subdivisions.

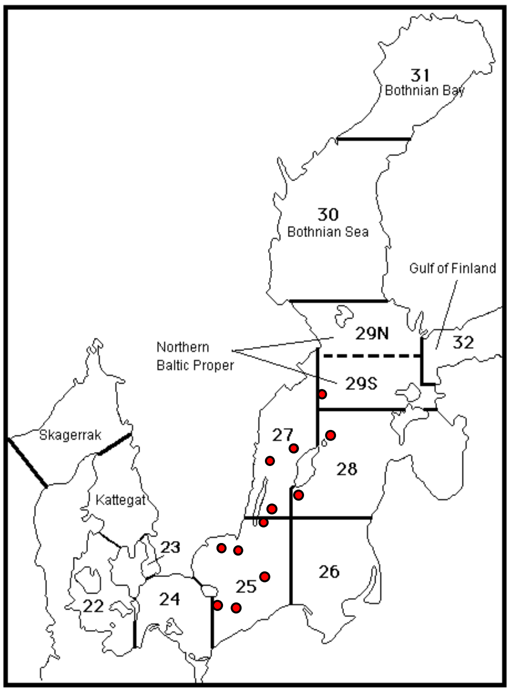


Fig. 1. The subdivisions of the Baltic Sea accordingly to the ICES classification

In accordance with the recommendations of the ICES Working Group FAST, simultaneously with the *in situ* experimental study of the *TS(L)* relationship in these subdivisions, modelling of the acoustical backscattering by the herring and sprat should be done. Accounting for that the backscattering significantly depends on the shape of fish individual swimbladder (Blaxter and Batty, 1990), the natural shape of the clupeids swimbladder in this area is critical in modelling. This motivates us to detailed study of clupeids swimbladder morphometry. The paper is addressed to the development of the methodology of the analysis of the accurate shape of the swimbladder.

## 1. MATERIALS AND METHODS

Study of the geometrical shape of herring and sprat swimbladders was performed only for fish from the Swedish coastal zone. The fish used in this study were collected by Nils Håkansson and Fredrik Arrhenius (National Board of Fisheries, Lysekil, Sweden) in October

2002 near the south-east coast of the Sweden. The stations are marked by the red circles on the study area map presented in Figure 1 (ICES Subdivisions 25, 27 and 29). The X-ray images of the collected fish were done in the Swedish Museum of Natural History in Stockholm. Subsequently, the best quality images of the twenty five herring individuals and twenty one sprat individuals were selected and the length, width and height of the body and swimbladder were measured (Fässler and Gorska, 2009). Difference in ontogenesis and physiology of Baltic clupeids in different regions of the Baltic Sea has been observed (ICES Reports 2004, 2005a, b, 2006a). This suggests geographical differentiation in the fish swimbladder shape. To accurately define the swimbladder shape of the clupeids in the Polish coastal zone, the appropriate research methodology should be developed, which does not impact on the natural shape of the swimbladder.

The methodology development is a challenge. Firstly, the swimbladders of fish caught from the large depths, which Baltic clupeids occupy, are distorted as a result of rapid changes in the hydrostatic pressure. Secondly, the way of fish storing before X-ray irradiation can impact on the swimbladder shape. Caught fish should be stored under the conditions (temperature, light, of oxygen concentration) similar to marine conditions in order to keep them alive in the best state. Thirdly, before the X-ray analysis the fish should be immobilized, not influencing the swimbladder shape.

### 1.1 X-RAY STUDY OF SOUTHERN BALTIC HERRING

***Study area. Material collection***

Fish were collected in October 2010 using a fishing boat HEL-125 in the area near the position: 54°37.345 N, 19°09.235 E (Fig. 2A). The fishing net towed behind the boat was applied. The fishing was carried on an average depth of about 16 meters and continued during less than an hour.

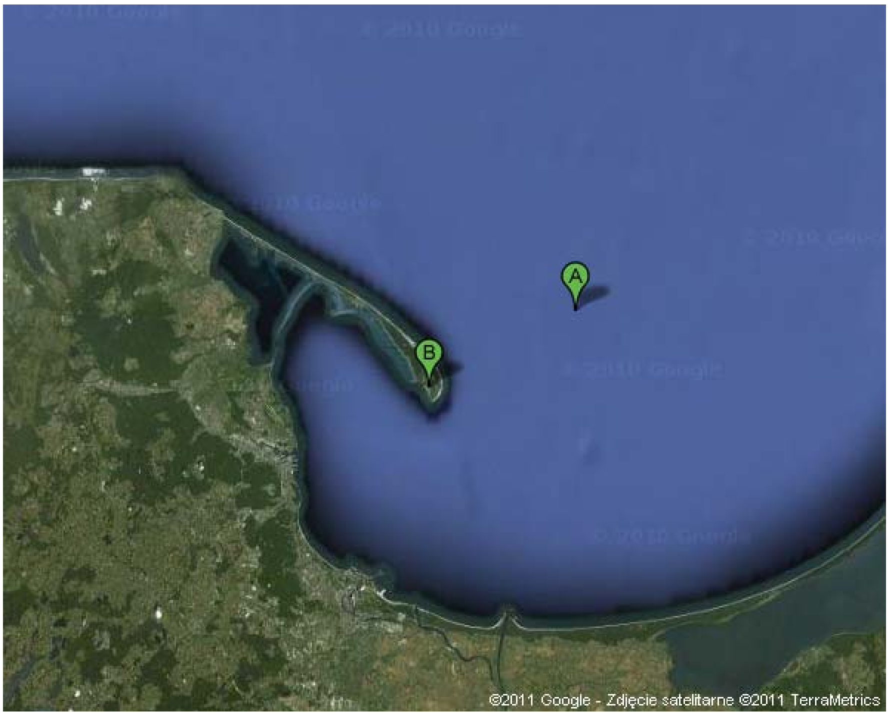


Fig. 2. Study area: A – herring fishing area (October 2010); B – place of fish storage and X-ray analysis (Marine Station in Hel, 115th Military Hospital in Hel)

### *Fish transport and storage*

150 fish individuals of the best condition were chosen (mainly herring) from the haul. These fish were placed into bags with oxygenated marine water in order to store them alive for X-ray analysis.

Just after arrival to the harbour, fish were located in a specialised aquarium in Marine Station in Hel (Point B in Fig. 2). Hydrological conditions in the aquarium were close to that in marine environment. Herring were kept in the aquarium during 12 hours. It allowed the fish to adapt to the new hydrostatic pressure conditions. Then fish were transported to the hospital where the X-ray irradiation was performed.

### *Fish preparation for X-ray analysis*

Herring X-ray study was done in the 115th Military Hospital at Hel. 105 fish from 150 caught individuals were analyzed. The other fish were eliminated because some of them did not survive transport to the hospital or had destroyed swimbladders. In the case of dead fish the swimbladder was not visible on the X-ray images or its shape strongly differed from the typical swimbladder shape of live herring. Sprat were excluded from the analysis because they did not survive transport to the hospital.

Following to the recommendations of the manual (Horne and Jech, 2001), just before the X-ray analysis, fish were placed for several seconds in the solution in order to anesthetize them. Solution consisted of 0.1 ml of clove oil and 0.7 ml of 40%-ethanol and 2 litres of water. It was important to immobilize fish but do not kill them. The anesthetization caused that the fish were calm during the X-ray analysis.

### *X-ray analysis*

X-ray images for two fish positions were done for each individual: the lateral and dorsal positions. The following X-ray machine parameters were set: applied voltage = 43 kV, product of the current through the X-ray tube (mA) and the X-ray exposure time (s) = 1.2 mAs. Construction of X-ray machine enabled the simultaneous X-ray study of a few fish (from 7 to 9 fish individuals depending on fish size). It resulted in decrease study time of all collected fish. Image on X-ray film was the final product. In order to identify individual fish the identification number was attached to the dorsal fin of each individual, which was visible on the X-ray image. Standard fish body size measurements were carried out just after the X-ray measurements. The total length, standard length, height, and width of the fish body were measured. Height and width were measured using caliper.

## 2. RESULTS AND DISCUSSIONS. MORPHOMETRIC CHARACTERISTICS OF SWIMBLADDERS OF BALTIC HERRING

At the next step, the X-ray images were scanned from X-ray film. Fish swimbladder dimensions were measured using the scanned X-ray images of the selected fish. The quality of the X-ray images of 28 herring individuals was satisfactory and these individuals were selected for further analysis. Examples of the images are presented in Figs. 3A and B.

The averaged ratios of $h_{sb}/L$, $w_{sb}/L$ and $L_{sb}/L$ of herring swimbladder, are respectively presented in Figures 4 A, B and C. Here $h_{sb}$, $w_{sb}$ and $L_{sb}$ are the height, width and length of fish swimbladder respectively, and $L$ describes total fish length. The difference in the morphometric parameters of swimbladders of herring caught in October 2002 during the Swedish component of the Baltic International Acoustic Survey (BIAS) in the Baltic proper (ICES Subdivisions

25, 27 and 29) (green bars) and herring caught in the Polish coastal zone (blue bars) is demonstrated. The standard deviations are marked by black lines in the plots.

The Figures 4 demonstrate that the average ratios $h_{sb}/L$ and $w_{sb}/L$ for the herring from the Polish coastal zone are smaller than for the herring from the Swedish coastal zone, but the average ratio $L_{sb}/L$ is higher for the herring caught in the Swedish coastal zone.

The morphometric difference between the herring from the considered two parts of the Baltic Sea could be the reason of the difference of their backscattering properties and the *TS(L)* relationships. It is important to study the impact of the morphometry difference on the *TS(L)* relationship. It would be done on the basis of the numerical modelling.

A)

B)

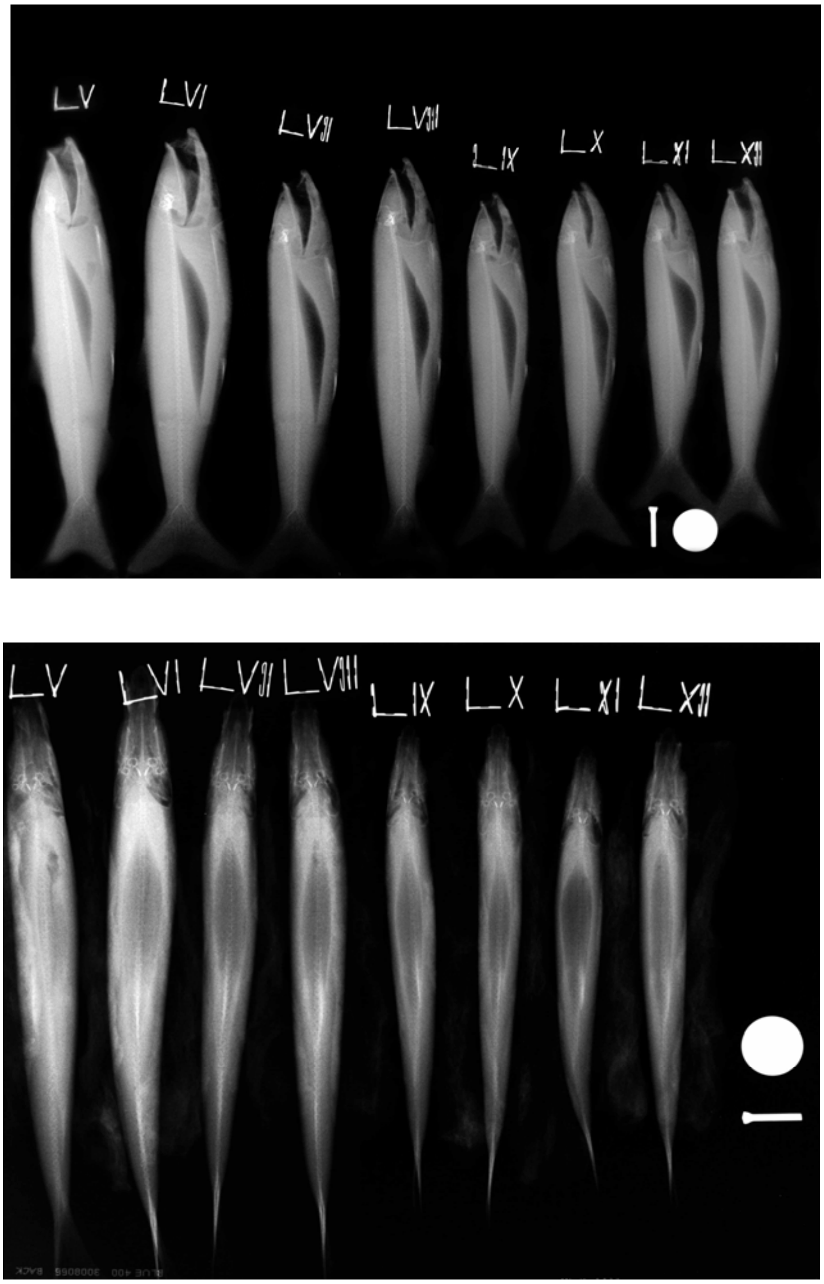

Fig. 3. Examples of X-ray images of herring: A – lateral exposure; B – dorsal exposure

A)
B)
C)

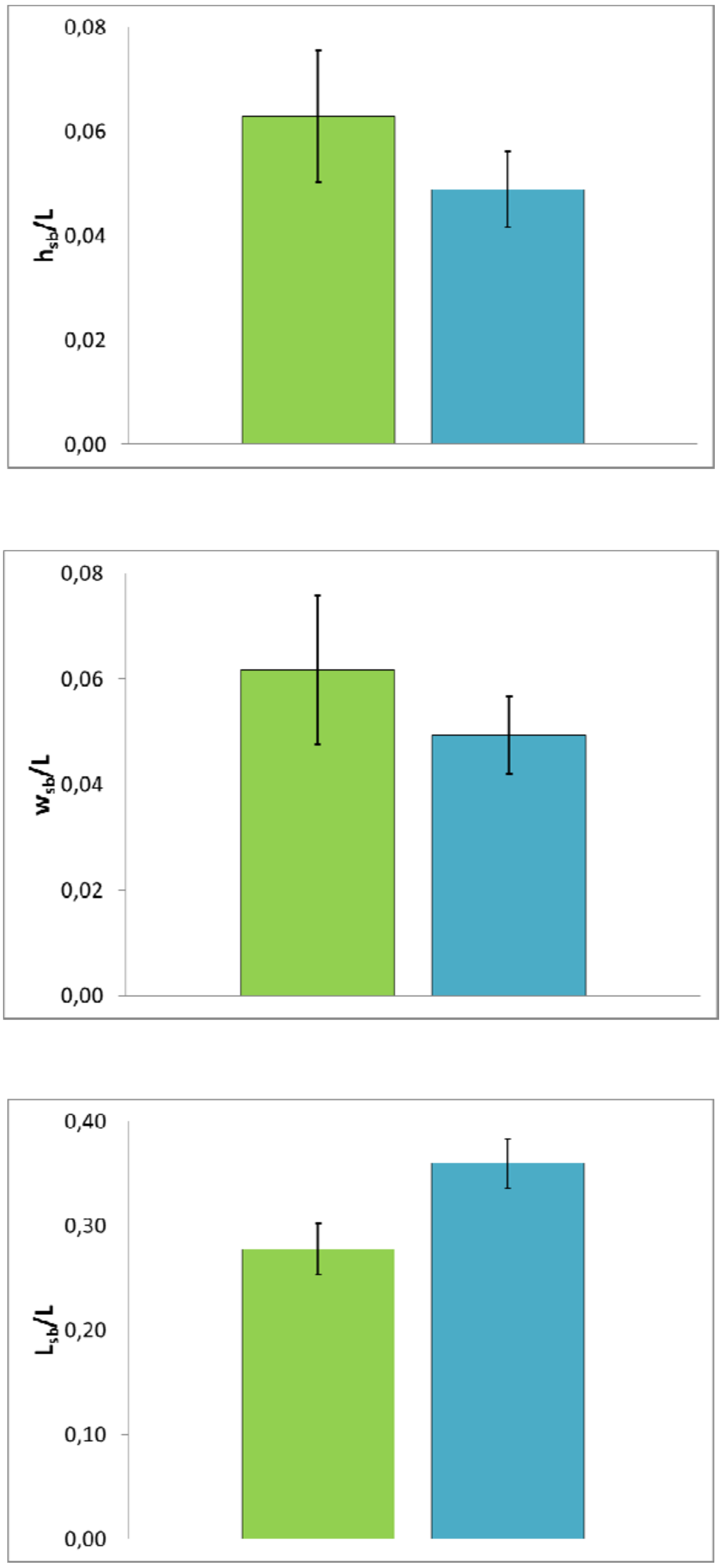


Fig. 4. Difference in swimbladder morphometry between the herring from the Swedish coastal zone (green bar) and herring from the Polish coastal zone (blue bar)

## 3. CONCLUSIONS

The methodology not influencing on the shape of fish swimbladder has been developed for study of swimbladder geometrical shape of herring collected in the Polish coastal zone. The optimal way of the fish catch, transport and storage, the X-ray measurements and the X-ray image analysis have been developed.

Basing on the developed methodology, the collection of X-ray images of herring and sprat caught in October 2002 during the Swedish component of the Baltic International Acoustic Survey (BIAS) in the Baltic proper (ICES Subdivisions 25, 27 and 29) has been expanded by the X-ray images of herring from Polish coastal zone (ICES Subdivision 26, for the fish stock assessment in which Poland is responsible).

The measurements of the geometrical dimensions of herring swimbladder have been done using the newly obtained X-ray images. These data would be used as the input data in the further modelling of the backscattering characteristic of the herring from the Polish coastal zone in order to define the *TS(L)* relationship, critical in the herring biomass estimation.

The comparison analysis of the images obtained for two considered parts of the Baltic Sea has been done. The difference in the swimbladder morphometry has been demonstrated for these two groups of herring. It could be the reason of the difference in the backscattering properties and the *TS(L)* relationships. It is important to study the impact of the morphometry difference on the *TS(L)* relationship, and it would be further done on the basis of the numerical modelling.

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