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Bubble sweep-down occurrence characterization on Research Vessels

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ABSTRACT

Bubble sweep-down on oceanographic vessels generates acoustic perturbations. We propose in this work to characterize the sub-surface bubbles occurrence conditions from acoustic data analysis acquired during surveys in relatively shallow water with the IFREMER research vessels Thalassa and Pourquoi Pas?. The methodology of data analysis used in this work allows us to characterize the sailing conditions influence on bubble sweep-down occurrence. The correlation between sailing conditions and acoustic perturbations tends to demonstrate that the presence of bubbles under the hull is clearly related to the wind speed and natural aeration, and that surface bubbles are advected differently in the water column by the two vessels.

1. Introduction

The generation of bubbles in the open ocean has been the topic of several works, most often motivated by a better understanding of gas exchanges with the atmosphere. Thorpe (2005) describes the fact that small bubbles, of radius less than about 1 mm, are stabilized by surface tension while those of larger radius are fragmented by shear stresses in the turbulent motion induced by the breaking event. The smaller bubbles rise very slowly and are consequently more persistent in the water column and often advected at a greater depth.

Movement of the surface ship bow is a source of air bubbles generation. While the ship is moving, these bubbles may be entrained under the hull where the transducers are mounted. This phenomenon of bubble sweep-down is an issue of major importance for oceanographic vessels designers. Air bubbles passing under sounders location may absorb or reflect the acoustic wave and be a source of inconvenient noise affecting sonar's data. Such disturbances strongly affect the productivity of some vessels dedicated to acoustic survey, as we can see in Fig. 1. In this figure we can see the perturbation induced on one ping for sea bottom detection by a multibeam sounder Reson Seatbat 7150 used at 24 kHz on the IFREMER research vessel Pourquoi Pas ?. The horizontal red line is the seabed detection at 2180 m depth: the detection is well marked without acoustic perturbation (Fig. 1 bottom) while it can be undetected for the perturbed ping (Fig. 1 top). In this extreme case, the acoustic wave is completely absorbed in the bubble layer and the transmitted pulse does not reach the seafloor, thus no echo can be observed. During the receiving time, the high noise level is attributed to the broadband noise of the bubbles collapsing in front of the transducer. This kind of perturbation is not only due to ship motions but by a combination of factors from which wave/bow interactions play an important part.

Many studies have therefore been dedicated to this topic since Dalen and Lovik (1981) who investigated bubble effects on biomass estimation of aquatic targets using echo-integration technique, first described by Dragesund and Olsen (1965) and now widely adopted in fishery research. The purpose of their work was to find an empirical formula that would enable the prediction of acoustic signal attenuation depending on weather conditions. Novarini and Bruno (1982) also studied the effect of bubbles layer on sound propagation. Later, New (1992) exposed the progress performed in oceanography thanks to the wider use of Acoustic Doppler Current Profilers on research vessels. However, New pointed out that problems remained under more or less bad weather conditions because of interferences generated by the near surface bubbles layer that can be overcome by lowering the transducer below the bubbles layer. Trevorrow (2003) developed in 2003 an analytical model to determine the influence of bubbles on high-frequency sonar performances. Finally, Shabangu et al. (2014) compared the attenuation of acoustic signals caused by bubbles for different sorts of transducer installations. Conclusions of these works are to recommend the installation of the transducers as deep as possible to avoid the under hull bubble layer and

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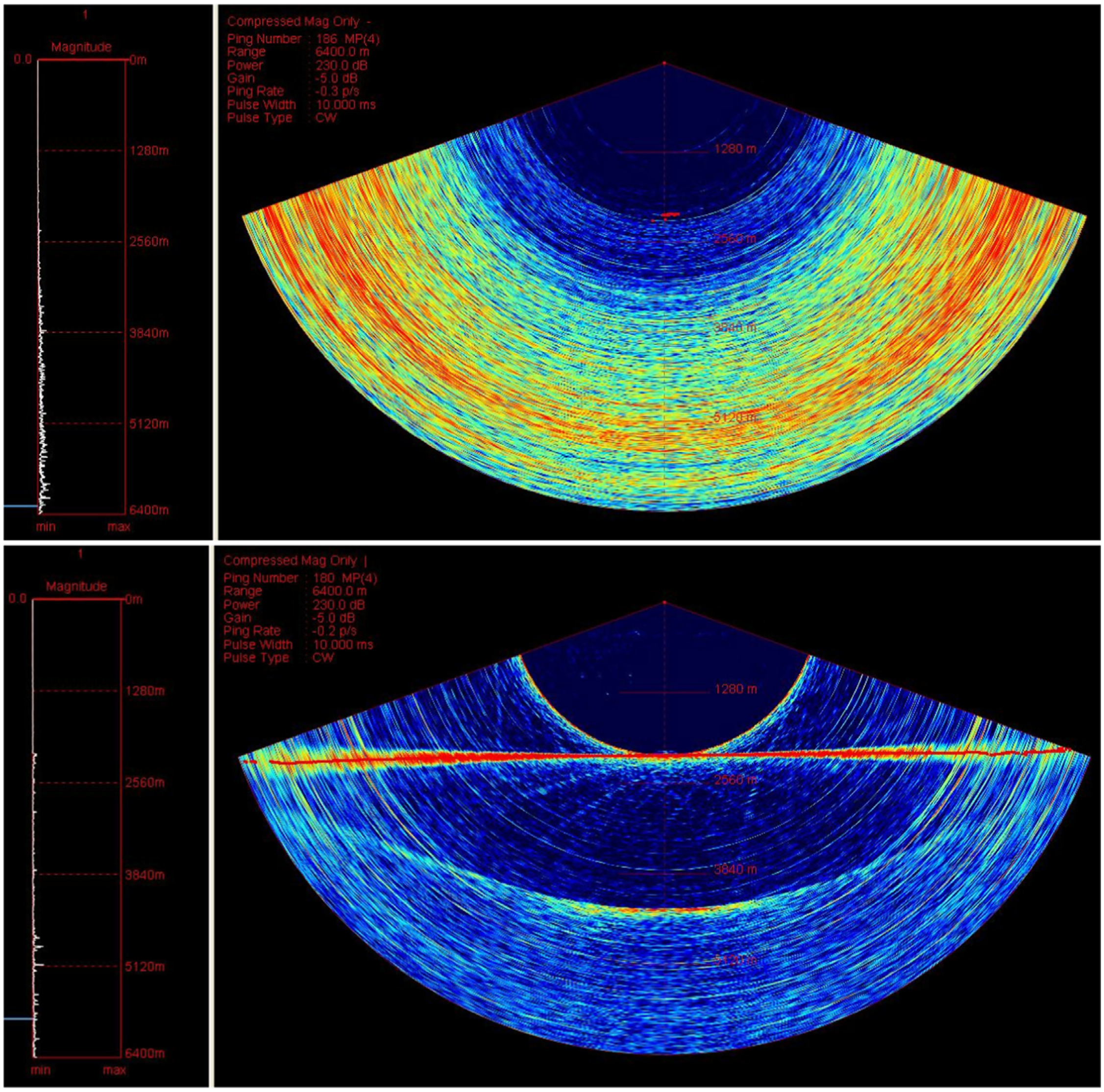

Fig. 1. Comparison between a "bubbled" ping (on top) and a non perturbed ping (bottom) from a multibeam sounder acquired in the same conditions on the Pourquoi Pas ? (dt < 1 min). The horizontal red line is the seabed detection. (For interpretation of the references to color in this figure caption, the reader is referred to the web version of this paper.)

significant acoustic signal attenuation for wind speed above 10 m/s. This solution is not always possible or efficient and solutions to minimize this phenomenon are still being sought (Rolland and Clark, 2010).

For that purpose comparison of bubbles generation should be undertaken for several oceanographic vessels. Nonetheless there are many parameters controlling this issue (hull characteristics, wind and sea state, heading, ship's velocity and motions, depth, etc.) and the conditions of occurrence of this phenomenon are consequently still poorly known. The objective of this study is to find a methodology for the analysis of acoustic data allowing the prediction of bubble generation under the hull of research vessels. Here we propose a first study to characterize the bubbles occurrence conditions.

The data used for this work come from the French survey series International Bottom Trawl Survey (IBTS) 2010–2013 undertaken in winter (January/February) in the Channel and the North Sea with the research vessel Thalassa. After the presentation in the second section of the equipments and the methodology of data analysis used in this work, the main results in term of sailing conditions influence on bubble sweep-down occurrence are exposed. The main advantage of direct measurement of bubble backscatter, over the method proposed by Shabangu et al. (2014) to measure the attenuation on the seafloor echo, is to avoid the influence of the variation of the seafloor backscatter for characterizing the attenuation and hence the bubbling. Once the bubbling is detected, prediction of attenuation can be done based on models of bubble size distribution and individual bubble backscattering cross-section (Weber, 2008). A correlation between wind speed, sailing conditions and acoustic perturbations is attempted and a comparison between the Ifremer research vessels, Thalassa and Pourquoi Pas ?, is given to prove the consistency of the methodology of acoustic data analysis for bubble sweep-down detection.

2. Material and methods

2.1. Eastern channel and north sea case study

The research vessel Thalassa is one of the main fisheries research vessel of Ifremer fleet. The primarily assignments of this vessel deal with fisheries-based missions such as population ecology and assessment of fish stocks. For this purpose, in addition