Acoustic lakebed classification using sonar5-pro

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Common techniques like grab samplers or video cameras permit to obtain the true nature of the substrate in a local point but they are not adapted to survey a whole lake.
Acoustic techniques have been developed to overcome this disadvantage (Poulain *et al.*, 2010) and the single beam echo sounder technology is the most appropriate in lake areas.
Sonar5-pro (Balk and Lindem, 2006), a post processing software commonly used by the research community to estimate fish biomass, had just implemented a module which calculate parameters necessary to apply a method developed by Orlowski (1984) based on the two first bottom echoes.

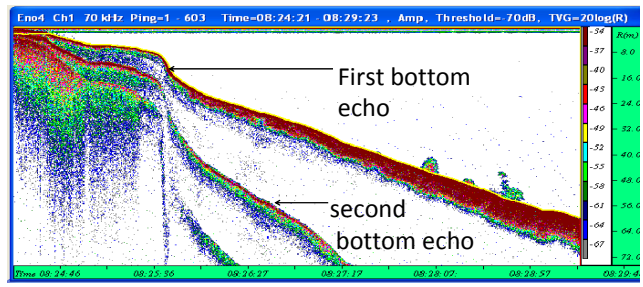

Figure 1: echogram example from EK60 analysed by Sonar5-pro.

Principle: extraction of two acoustic parameters, E1 and E2, related to the two first bottom echoes (fig. 1). E1 gives information about the roughness of the substrate, E2 is an indicator of the hardness, contributing both to the description of a sediment type. A first step is to create a database of couples [E1;E2] associated with true nature of lakebed (fig. 2) by an *in situ* validation, i.e. a calibration of the system. When a large range of sediment have been implemented in the data base, we use it to compare the [E1;E2] of an unknown area to attribute a nature to each couple.

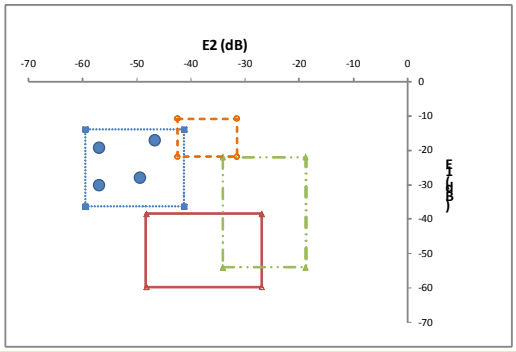

Figure 2: visualization of characteristic areas of each substrate nature in the [E1;E2] space. Blue rectangle: limits of the mud area; orange rectangle: limits of the blocs area; green rectangle: limits of the sand + stones area; red rectangle: limits of the sand area.

Reference database : From March to June 2010, 7 surveys on 3 French lakes (Leman, Bimont and Bourget)
Acoustic device : Simrad EK 60 echo-sounder, 70 kHz acoustic wave frequency, power: 400 W, pulse length: 0.512 ms
Four different types of substrate acoustically distinguished: mud, blocs, sand, and sand + stones.

Figure 3: An Ekman grab sampler and images from a video camera were used to do the *in situ* validation.

Application: In June 2010, a 3 km² area in the lake Leman known to be an arctic charr (*Salvelinus alpinus*) spawning area (Rubin, 2005) was surveyed (fig. 4). Ship speed of 4 knots maximum (speed used during fisheries surveys). Extrapolation allow then to draw a map of the 4 substrates of this spawning area (fig. 5).

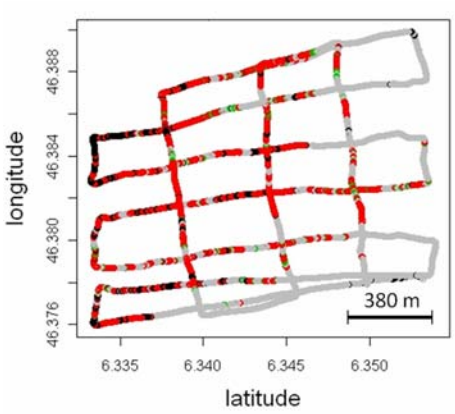

Figure 4: representation of the sediment natures along the transects.

Grey: mud; red: blocs; green: mud or blocs; black: unknown.

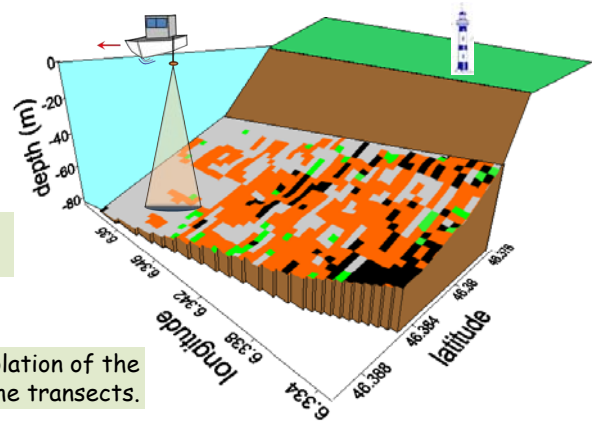

Figure 5: interpolation of the result between the transects.

Conclusion: Sonar5-pro, a standard software used by a lot of Scientifics, is a useful tool to classify substrata of lakebeds. Evolutions in time and space of fish spawning areas could be done, particularly on restored sites, as *artic charr* spawning areas in lake. Knowledge of the entire lake substrata by this method can help to assess ecological quality of a lake.
More studies must be carried out to add other substrata natures in the present reference database and then to precise the resolution of discrimination.

-Balk, H., Lindem, T., 2006. Sonar 4, Sonar 5, Sonar 6 – Post-processing Systems. Operator Manual. University of Oslo, Norway, 427p.
-Orlowski A., (1984)" Application of multiple echoes energy measurements for evaluation of sea bottom type". Oceanologia 19, 61–78.
- Poulain T., Argillier C., Guillard J., 2010, Classification des fonds lacustres par hydroacoustique. Rapport bibliographique. 29p.
-Rubin J. F. (2005), « Les sites de reproduction de l'omble chevalier du Léman ont-ils évolué de 1981 à 2005 ? ». Archives des Sciences 58, 201-230.