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Mills cross multi split-beam processing for assessment of target strengths

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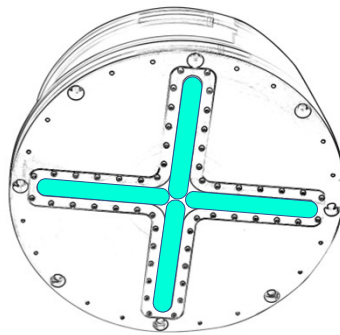
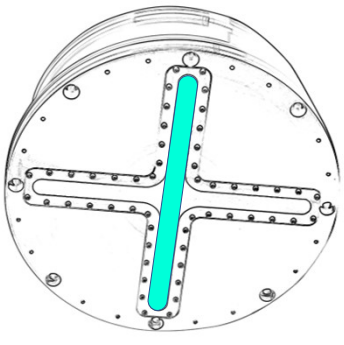
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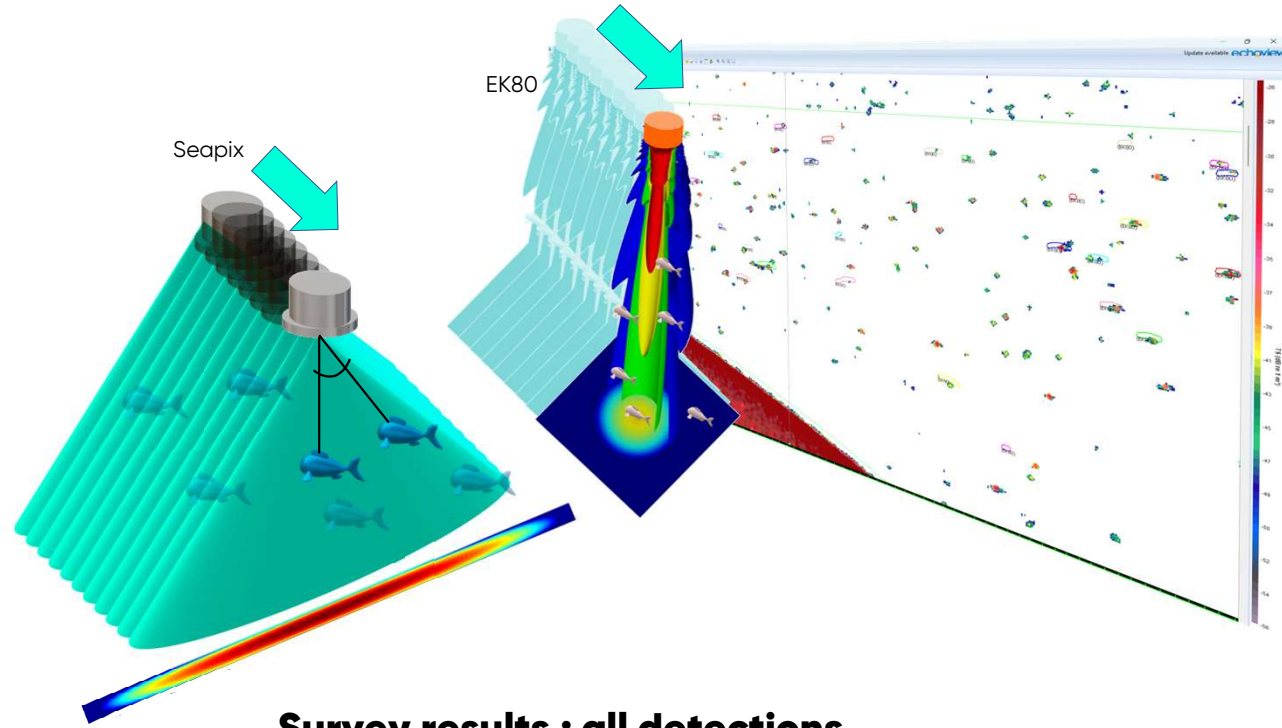
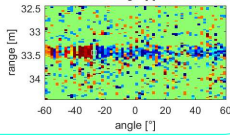
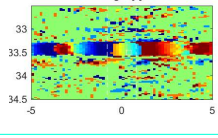
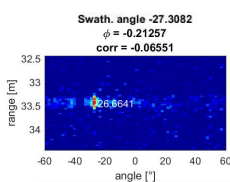
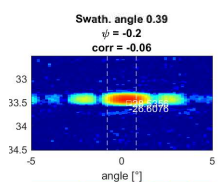
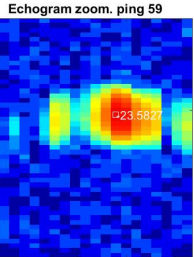
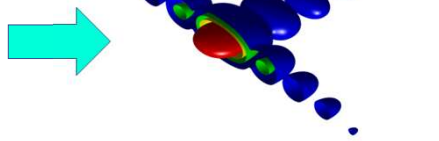
Seapix

Transmitted beam with the transverse antenna

Received beams from all parts



3D Point Spread Function or acoustic pixel

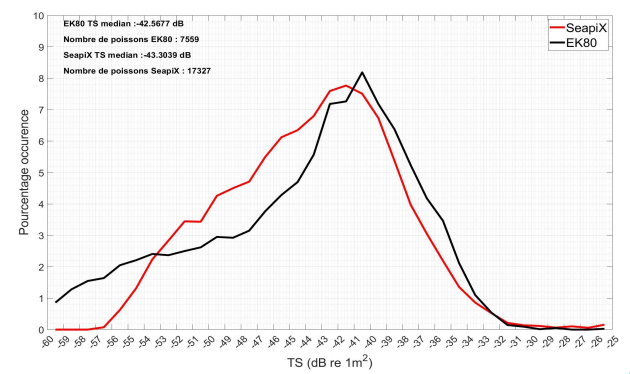


Survey results : all detections

In order to evaluate this method on fish data, a survey was conducted together with INRAE team on Lake Bourget, simultaneously with Seapix (150 kHz) multibeam echosounder and EK80 (120 kHz) split beam echo sounder (SIMRAD). Both hydroacoustics recording were processed with Echoview®.

Prior to the survey and afterwards, TS calibration was performed on the calibrated target. Environmental parameter did not change during the acoustic survey (temperature, salinity, pH).

7 559 targets were extracted from split beam EK80 and 17 327 targets were extracted from Seapix data over the whole swaths. The overall probability density function are superimposed on this figure.



Principle

The target angle $\theta_{Rx_{real}}$ is accurately measured within each beam using this formula

$$\theta_{Rx_{real}} = \theta_{Rx} - \sin^{-1} \left(\frac{\psi_T \lambda}{\pi L \cos \theta_{Rx}} \right)$$

Echo level equation

$$EL_n(t) = 20 \log_{10}(S(t)) - G(t) - RVS - F$$

Target strength equation

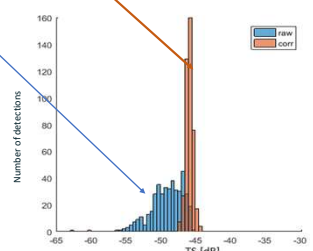
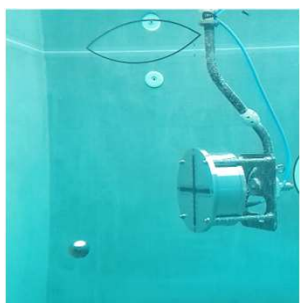
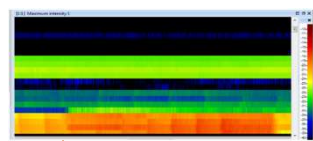
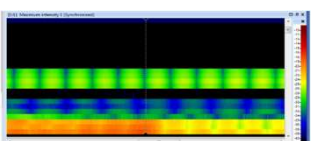
$$TS_n(t) = EL_n(t) - SL + 40 \log_{10}(r) + 2\alpha r + C_n - 20 \log_{10}(\text{sinc}(\psi_L) \text{sinc}(\psi_T))$$

Target strength of all acoustic pixels is calculated, and interferometric measurement (or split beam phase) is exploited to recalculate the accurate position of the target within each receiving beam. The split beam phase is also exploited to compensate the TS level of each detection.

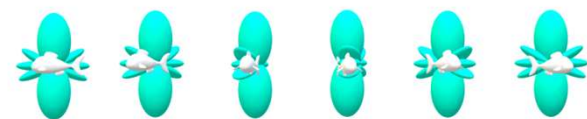
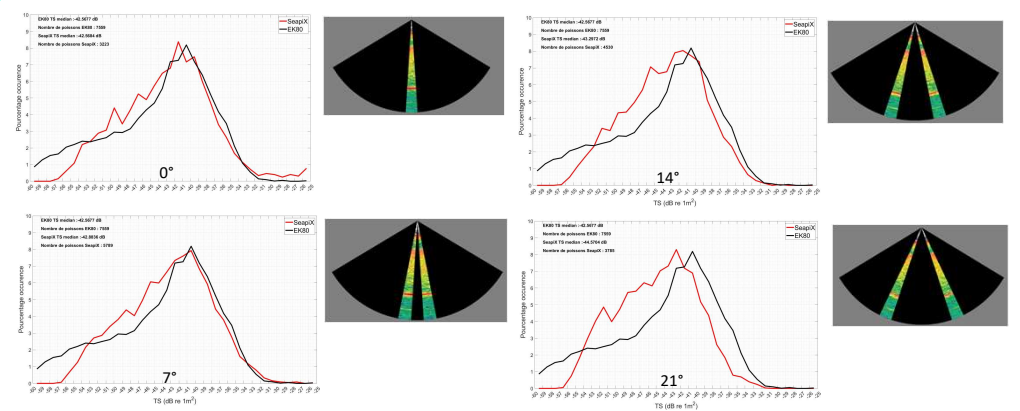
Variable definition	
$\theta_{Rx_{real}}$	exact target position within the beam
θ_{Rx}	centre position of beam receiving angle
λ	wavelength of the pulse (around 1 cm for Seapix)
L	antenna length (.35 cm for Seapix)
n	beam number
$S(t)$	measured signal
$G(t)$	time variable gain
RVS	Receive voltage response [V]
F	chain factor conversion [bits/V]
r	range
α	absorption of sound
ψ_L	split beam phase in longitudinal direction
ψ_T	split beam phase in transverse direction

Lab results

Water tank experiments have been conducted in order to validate the compensation of interbeam variability and the compatibility with the diffraction model from a linear array. Seapix multibeam was installed on a rotation stage and pulse echo measurement were acquired on a target sphere (21 mm tungsten carbide sphere). Implementing the correction on a this calibrated target was proved to be successful.



Survey results : angle dependent TS



Targets extracted regardless of beam direction exhibit the same modal distribution that traditional EK80 survey. A slight shift in the distribution toward lower TS comes from fish statistical angular response.

Considering the 0° beam only (non steered), TS distribution from EK80 (120kHz) and Seapix(150 kHz) are superimposed. For higher steering angles (7 to 21 °) it is clear that the scattering contribution does not come only from dorsal scattering, hence the shift towards lower TS measurements.

Conclusion

Seapix data is compatible with data acquired with conventional split beam echo sounder. In that manner, historical data acquired over the years using conventional hydroacoustics methods could be compared to actual Seapix data.

The additional information provided by Seapix is the spatialization of biomass over +/- 45°, accompanied by an accurate TS measurement. This large acoustic coverage enables the detection of more targets over the same survey.

Furthermore, this property could also be interesting to evaluate the avoidance behavior of some fish species subjected to a consequent fishing effort and which have developed this defense strategy.