**Postdoc proposal - Numerical modelling of fish otolith accretionary growth**

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**Duration**: 18 months (expected commencement date: may 2007)
**Location**: Ifremer Brest, France

Fish otoliths, calcified structures located in the inner ears of the fish, are actual biological and environmental archives, (Druffel 1997; Campana and Thorrold, 2001). Their accretionary growth results from a strict physiological control of the organism, but is influenced by the environmental conditions in which the fish lives. For instance, environmental variables such as temperature and salinity, as well as season-based or age-based metabolic variations are known to influence the deposit rate and the incorporation of chemical elements. This accretionary process often leads to the formation of a sequence of structures (rings), whose periodicity goes from the day to the season. Otolith analysis then offers a unique potential to reconstruct, at a daily and/or yearly scale, environmental parameters as well as individual life traits (age, growth patterns, migration patterns,…), and provides the mean to acquire information at different biological level : the individual level, in terms of individual life traits, the population level regarding age-based population statistics or spatio-temporal population structures, the environmental level in terms of reconstruction of temporal series of environmental parameters. Several million of otoliths are thus analyzed yearly worldwide for fish stock assessment as well as ecological studies.
Although otolith analysis is now recognized as an invaluable source of information, the decoding of the metabolic and environmental information archived by the otolith remains critical and new tools are needed to access a robust calibration of the archive. The last decade has mainly focused on the detection of significant statistical links between environmental and/or metabolic conditions and otolith signatures. Such an empirical framework actually led to significant scientific advances (eg,, the calibration of $\delta^{18}O$ signal as a proxy of the temperature). However, in most situations, the otolith signal remained non-interpreted. These difficulties stress the needs for characterizing and understanding the biological basis of the biomineralization processes.
Within the framework of the project OTOCAL funded by the French National Research Agency, the opened postdoc position will cope with these issues through the analysis and the modelling of the processes involved in the otolith formation, and of their modulation by environmental factors and the physiology of the organism. It will lead to the development of a numerical otolith growth model viewed as a simulation tool of the underlying processes. It will benefit from recent advances in the characterization of the biomineralization process and of the organic fraction of the otolith (Murayama et al. 2005 ; Payan et al. 2004). From a formal point of view, the numerical approach will rely on the definition of a dynamic model of otolith growth with a view to relating otolith features (eg, shape, opaqueness, chemical signatures) and endolymph features (eg, ion and protein concentrations) to environmental factors (eg, temperature, food availability). Coupling with existing dynamic energetic budget model might be investigated. The otolith growth model is intended to provide a simulation tool towards the understanding.
European hake will be the biological model, for which both field (tagging-recapture) and tank experiments are currently undertaken (de Pontual 2006). While analysis and model calibration phases will rely on the study of the biological material issued from experiments in controlled environments, an extension to samples from the wild will be considered (especially, recoveries associated with DSTs (Data Storage Tags).
This postdoc position is opened at Ifremer/LASAA in Brest (LASAA, www.ifremer.fr/lasaa). The successful candidate will benefit from a highly multidisciplinary environment (eg, otolith research, biomineralization, biogeochemistry, marine ecology, computer vision,…) and from the existing collaboration with the CERV (European Center for Virtual Reality, V. Rodin, Brest) regarding simulation aspects.

## Educational background and skills

Phd in computer science (eg, applied modelling, numerical simulation, signal processing) with strong interest for marine and biological applications OR Phd in marine biology with a strong background in mathematical modelling
Computer skills : C/C++, Matlab

**Gross salary (before tax) :** From 2100 to 2600 euros monthly depending on experience

## References

Campana, S.E., et Thorrold, S. (2001). Otoliths, increments and elements: keys to a comprehensive understanding of fish populations? Can. J. Fish. Aquat. Sci. 58:30-38

de Pontual H., Groison, A.L., Piñeiro, C., and Bertignac M., 2006. Evidence of underestimation of European hake growth in the Bay of Biscay, and its relationship with bias in the agreed method of age estimation. ICES Journal of Marine Science, in press.

Druffel, E. (1997) Geochemistry of corals: proxies of past ocean chemistry, ocean circulation, and climate. 94 (16) Proceedings of the National Academy of Sciences of the United States, 8354-8361.

Fablet, R., Chessel, S. Pujolle, A., Benzinou, A., Cao F. (submitted).2D Image-based reconstruction of accretionnary growth using a variational level-set approach: application to fish otoliths.

Hüssy K., H. Mosegaard, et F. Jessen (2004). Atlantic cod (Gadus morhua) growth and otolith accretion characteristics modelled in a bioenergetics context Can. J. Fish. Aquat. Sci. 61: 1021–1031 (2004)

Murayama, E., Herbomel, P., Kawakami, A., Takeda, H., et Nagasawa, H. (2005). Otolith matrix proteins OMP-1 and Otolin-1 are necessary for normal growth and their correct anchoring onto the sensory maculae. Mechanisms of Development.

Payan P., de Pontual H., Boeuf G., Mayer Gostan N. (2004) Endolymph chemistry and otolith growth in fish. Comptes Rendus de l'Académie des Sciences, Palevol, 3 (6-7): 535-547.