An Individual Based Model of anchovy early life stages in the Bay of Biscay: validation of vertical distribution and growth

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Introduction

- Objective: better understanding of recruitment variability in anchovy population
- An Individual Based Model (IBM) is being developped for the full life cycle of anchovy. The early life stages are presented on this poster.
- The model is tested in a 1D-vertical framework for validation of the vertical distribution of modelled eggs and larvae against *in-situ* data.
- The dynamic Energy Budget (DEB) theory is the biological baseline for individual growth. We test its ability to simulate the observed growth curves between years with contrasted temperatures.

Data

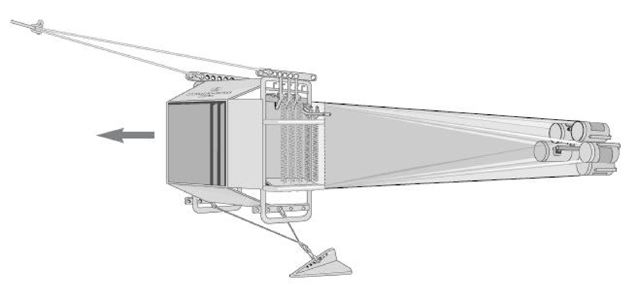


Figure 1: Multinet (Hydrobios, 2005) for vertical sampling of eggs and larvae.

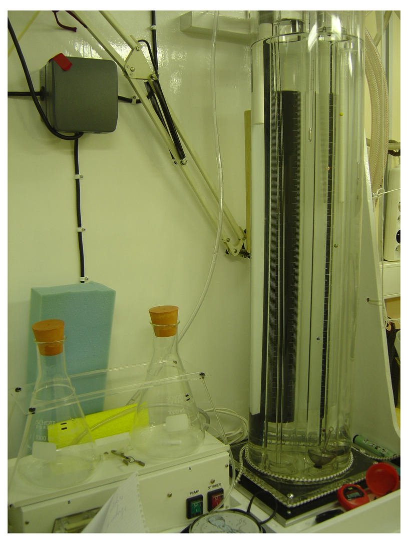


Figure 2: Density column for egg density measurement.

Figure 3: Anchovy larva.

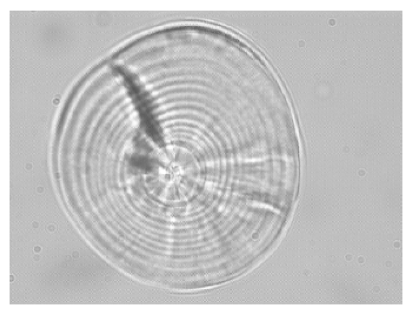


Figure 4: Larval otolith providing age and growth rates.

The Bay of Biscay

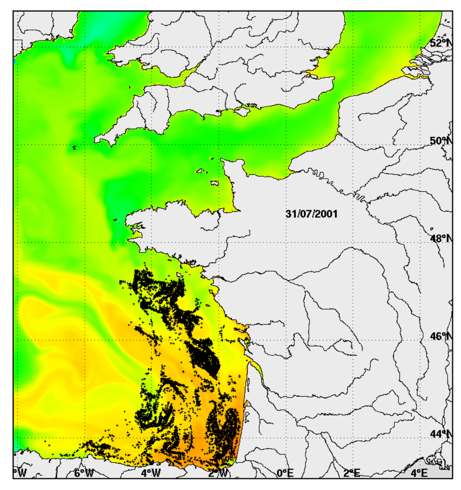


Figure 5: The model domain with example of particle distribution after one month from shelf spawning.

Observations of vertical distribution and egg density

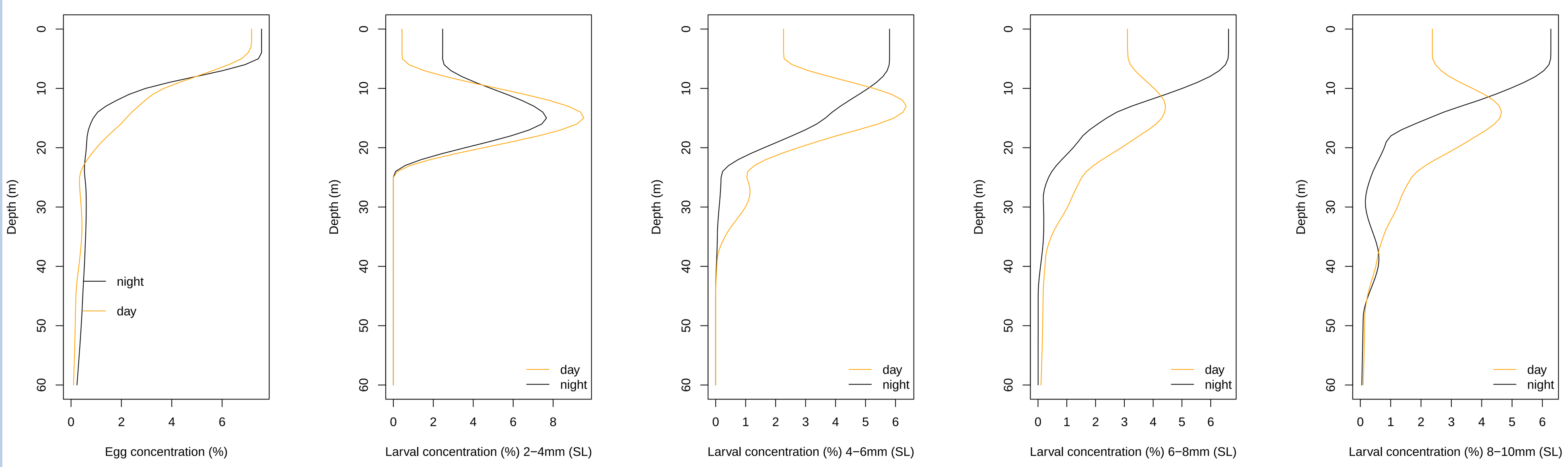


Figure 6: Day/night vertical distribution for eggs and different larval sizes.

- Eggs are almost exclusively concentrated in the first 10m
- Vitelline larvae are concentrated around the pycnocline
- The nycthemeral migration is significant from the 6-8mm size range.

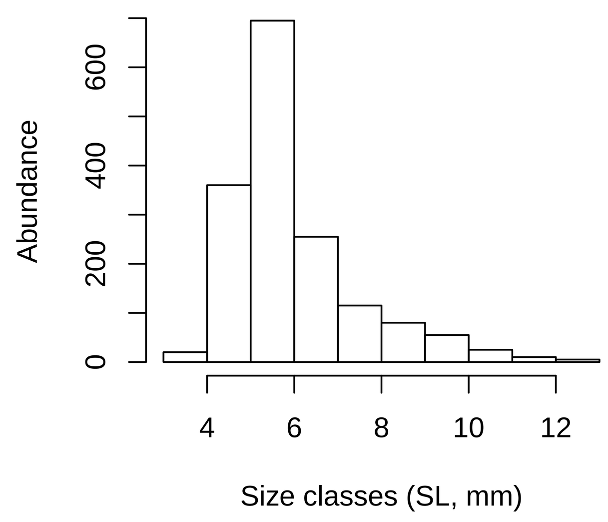


Figure 7: Frequency distribution of size of sampled larvae.

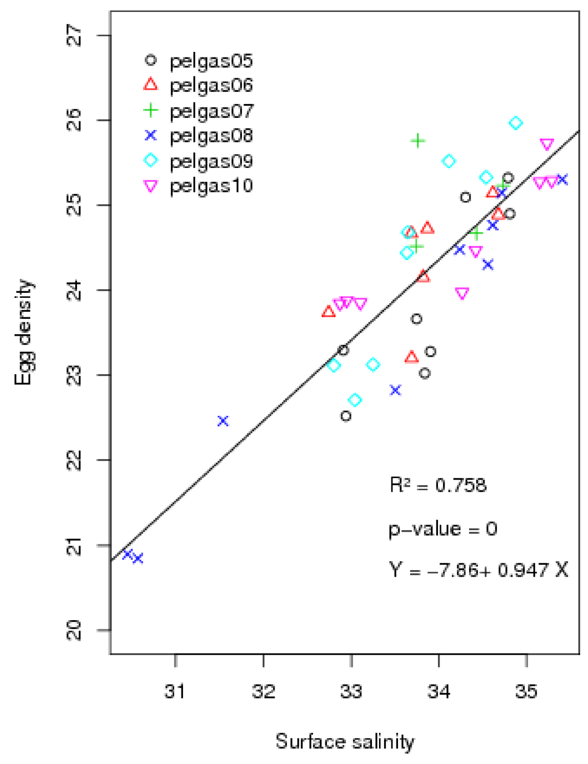


Figure 8: Relation of egg density with sea surface salinity from different years (completed from Goarant et al., 2007).

- The 1D vertical model if constrained by egg density, hydrology profiles from CTD casts as well as wind and tide for vertical mixing, following Petitgas et al.(2006) but in a Lagrangian framework for individual particle tracking.
- Egg density is prescribed at spawning from its relation to sea surface salinity (fig.8) as measured with the density column (fig.2).

Model of vertical distribution

The early life stage model is made of three successive stages:

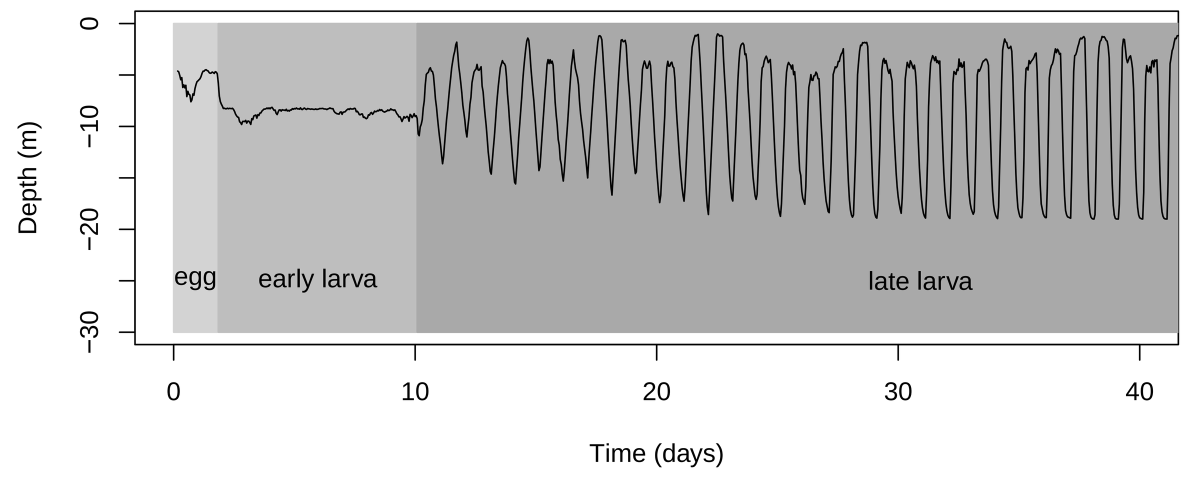
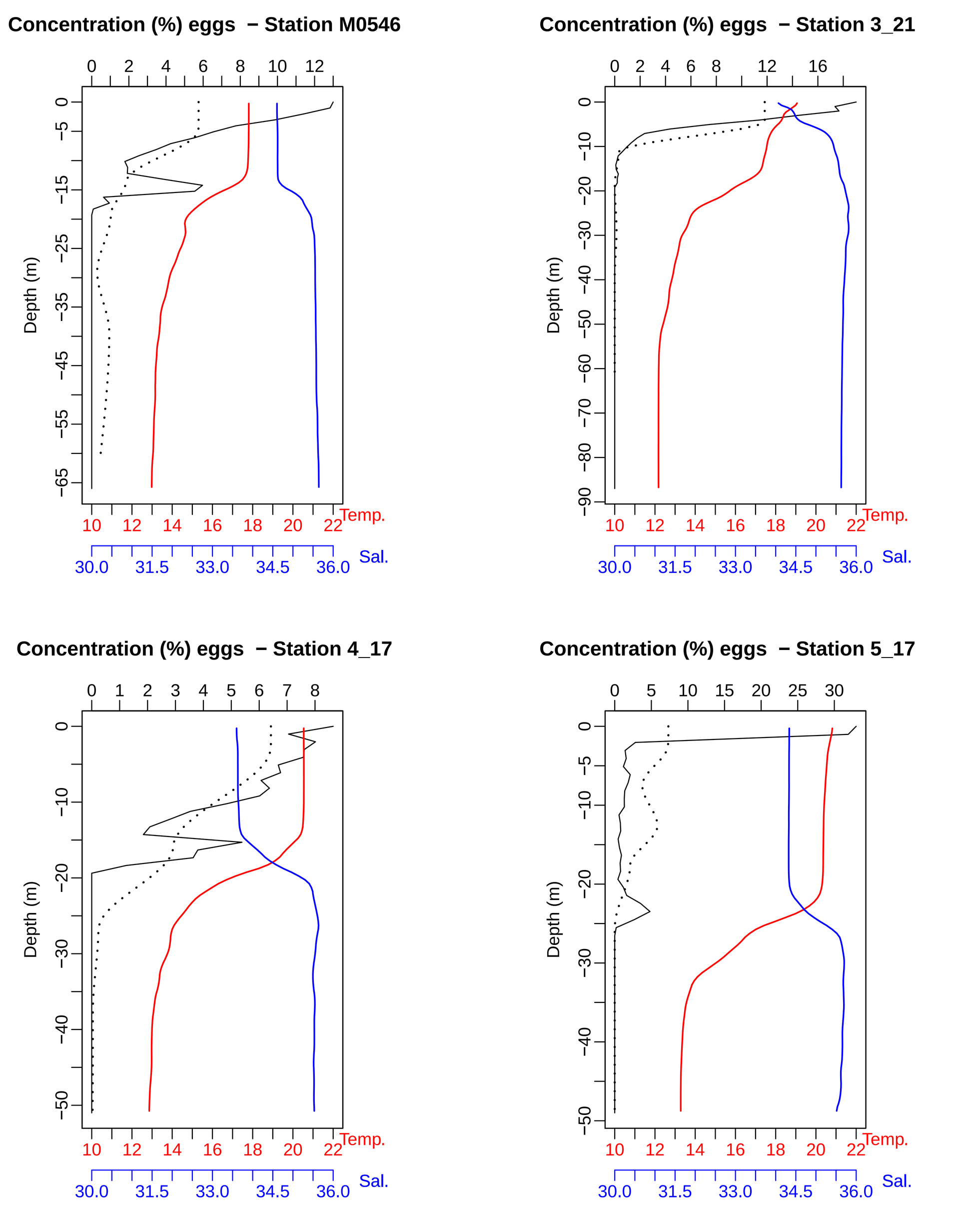


Figure 9: Mean (from 100) particle distribution along development stages. Egg density depends on surface density at spawning and drops down before hatching. Early larvae are passive. Post-flexion larvae swimming speed is size dependent, from 6mm SL.

Validation of the egg vertical distribution at individual stations:



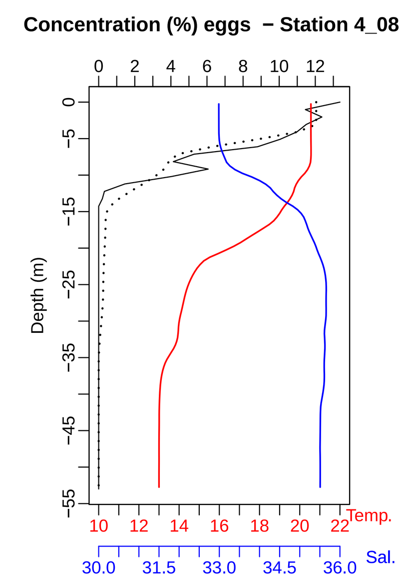


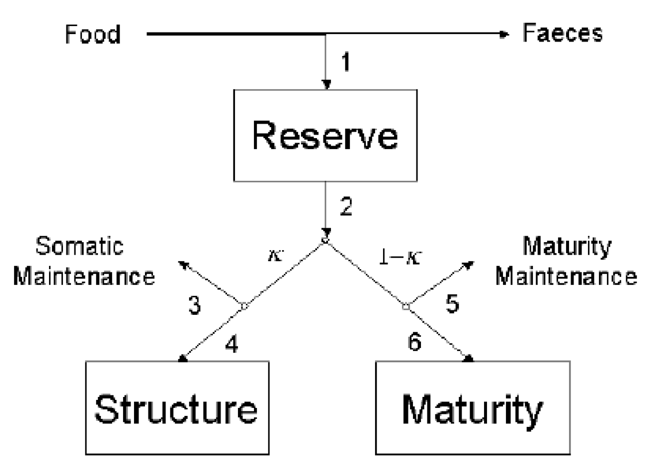
Figure 10: Comparison of modelled and observed egg vertical distribution at several stations from 4 different surveys in 2008 (May, June, July and August) with different T and S profiles.

.... Observed distribution
—– Modelled distribution

- The model simulates the vertical distribution pattern in surface layer at most stations
- Max at surface and pycnocline difficult to validate with the vertical resolution of the multinet.

Modelling growth

The standard model of the DEB theory (Kooijman, 2000) describes the rate at which the organism assimilates and utilizes energy for maintenance, growth and reproduction. This model is based on the κ-rule which states that a fixed fraction k is allocated to somatic maintenance and growth, with priority for maintenance while $1-\kappa$ is allocated to maturity development during the early stages and reproduction and maturity maintenance during the adult stage. A specific module was built for otolith growth.



1 | Assimilation p_A
2 | Reserve utilisation p_C
3 | Somatic maintenance p_M
4 | Growth p_G
5 | Maturity maintenance p_J
6 | Development p_R
κ | Fraction to growth and somatic maintenance

Figure 11: Energy fluxes through an individual at the larval stage for anchovy based in the DEB theory (Pecquerie *et al.* 2009).

- The model simulates the mean pattern of growth between somatic length and otolith radius.
- The model simulates the mean pattern of growth between years with different mean temperatures.

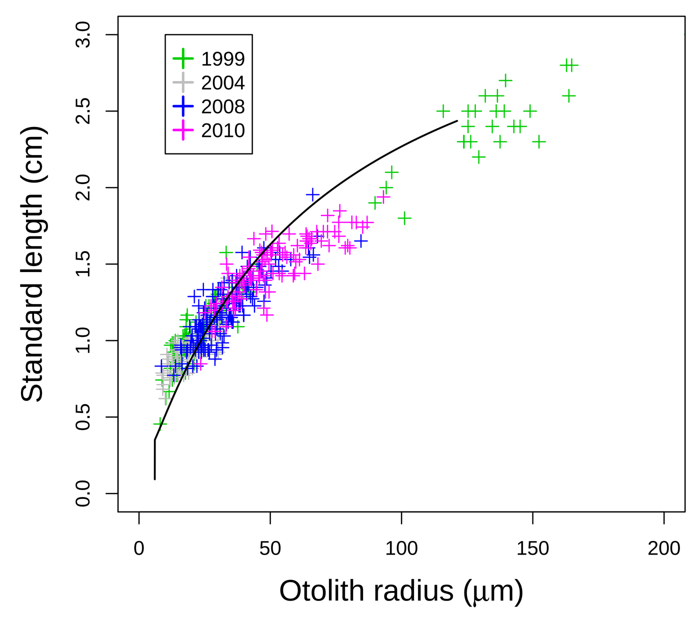


Figure 12: Measured larval standard length vs. otolith radius from several years (+) and simulated relationship with the DEB model (continuous line).

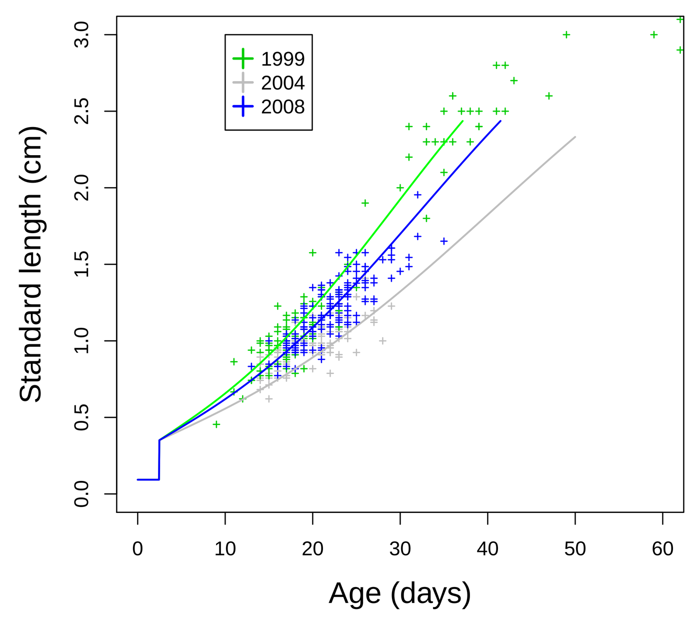


Figure 13: Measured larval length (SL) at age from several years (+) and simulated with the DEB model (continuous lines) run with mean temperature of respective years.

Conclusions - Future work

- The growth model will be tested on individual trajectories from otolith daily growth rates
- The IBM model will be run in 3D over the model domain of fig.5 and several contrasted years
- Trophic coupling with a lower trophic level model (ECO-MARS) based on zooplankton size spectra
- Mortality will be parameterized with size and growth dependence
- The full life cycle will be coupled through the DEB approach (Pecquerie et al., 2009)

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