

Responses of anchovy larval dispersal to climate change scenarios in the Bay of Biscay

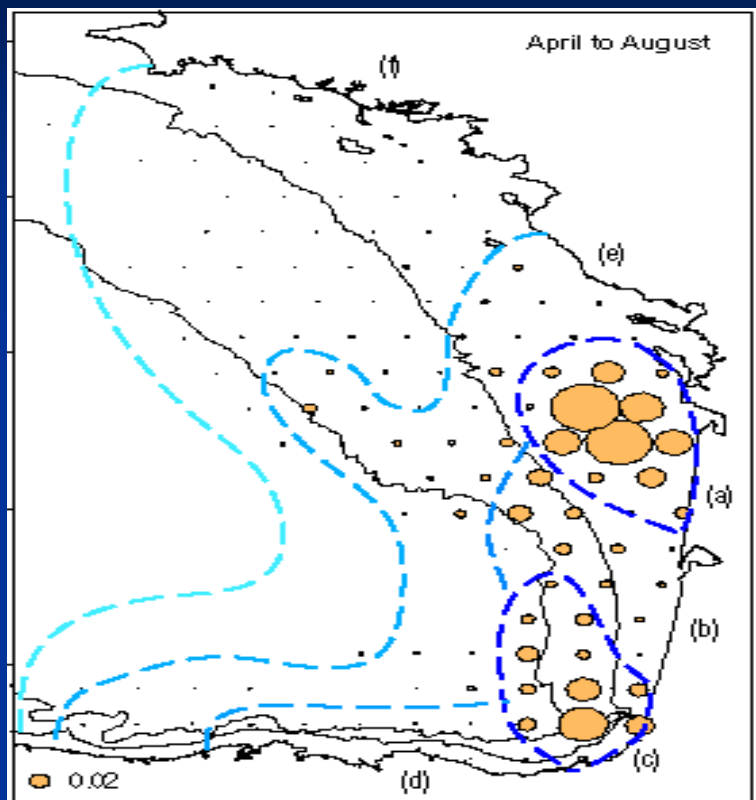
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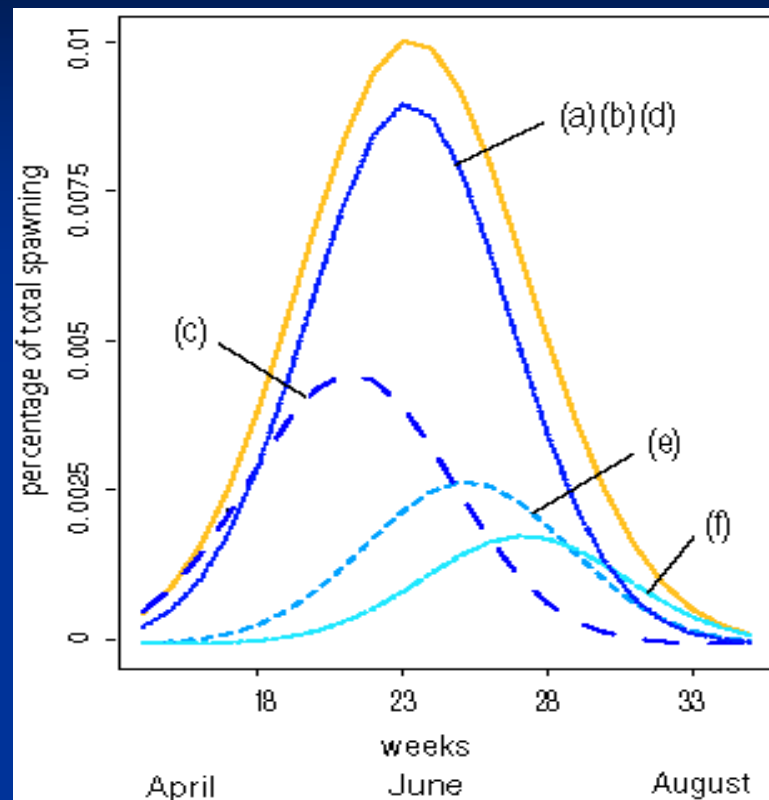
- Larval dispersal drives connectivity among marine populations.
- Key part of the recruitment variability
- Modifications of the dispersal in the context of climate change ?
- Current trend : $\sim 0.3^{\circ}\text{C}$ per decade from 1985 (*Saulquin and Gohin, 2008*)

- **Indirect : Reduction of PLD** (Planktonic Larval Duration) through change of biological traits
- **Indirect : Change in phenology** (i.e. shift in the spawning season)
- **Direct : Modification of circulation patterns** through currents, stratification changes

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Mean egg abundance



Spawning curve

Spawning start : Temperature increase (from 13-14°C) and stratification setup.
Koutsikopoulos et al. 1996 ; Motos et al. 1996, Sc. Mar.

- **Model MARS-3D**

- Horizontal resolution : ~4 km
- Vertical resolution : 30 sigma levels

- **Forcing**

- Daily river run-off
- Meteorological model : ARPEGE 0.5°

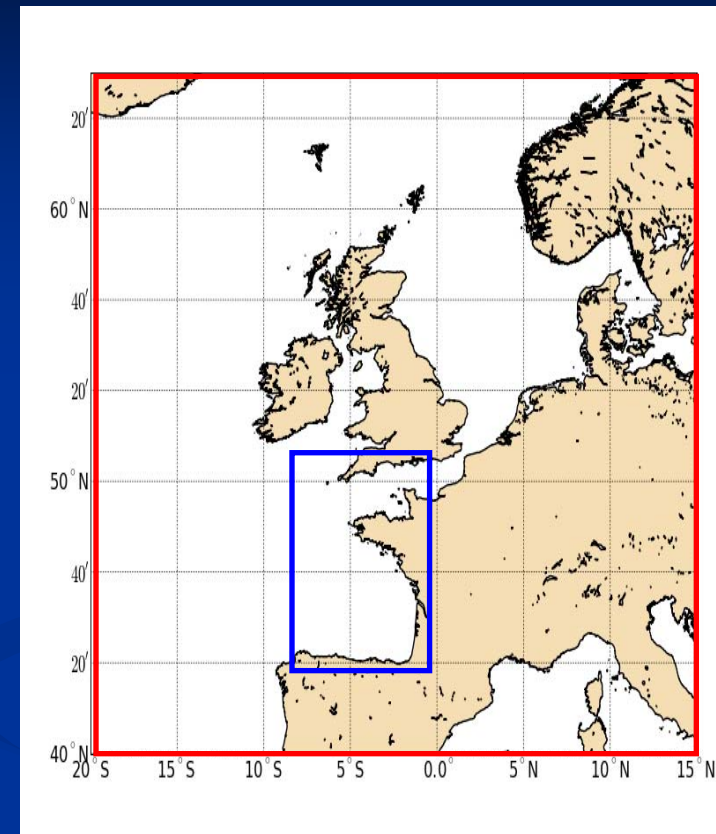
- **Reference run : 1996 -2007**

- **Scenarios : forcing from 2001-2002**

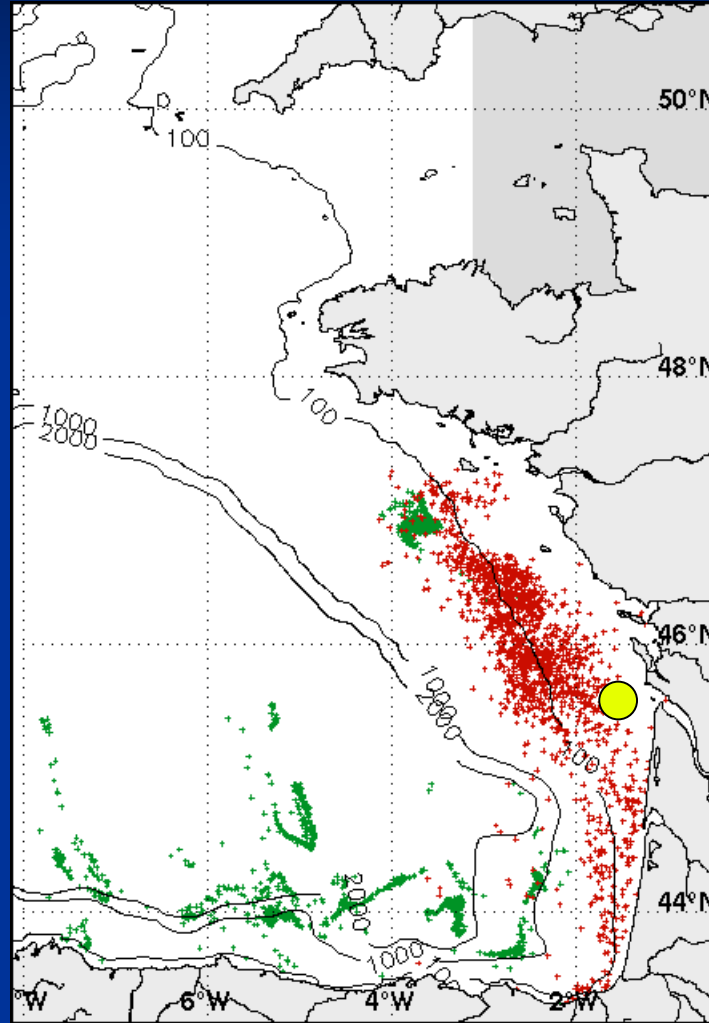
- Air temperature +3°C
- Wind +30%
- Combined : Air temp. + Wind
- River discharge +40%

- **Lagrangian module**

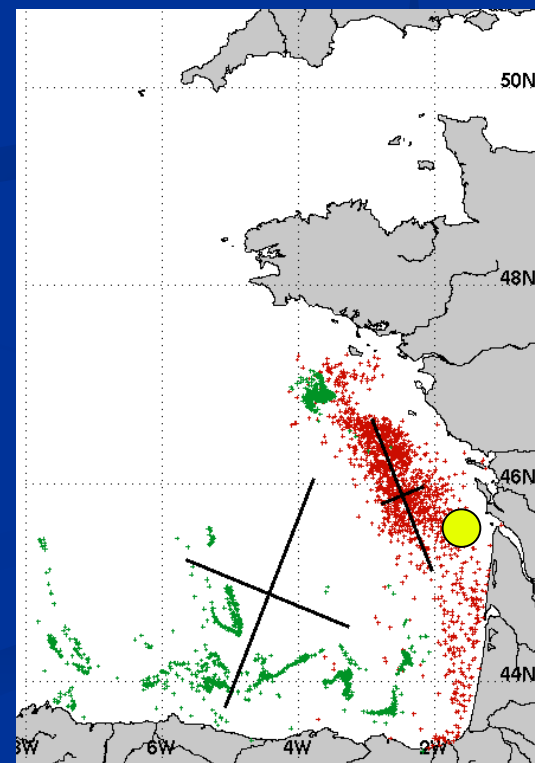
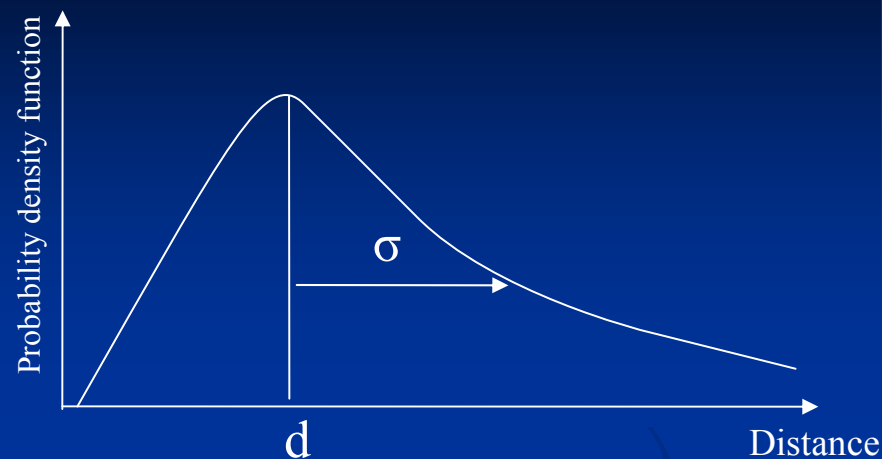
- Large number of particles released between surface et 30m
- Random walk for particle mixing
- Simplified day/night migration
- PLD vary between 20 and 60 days



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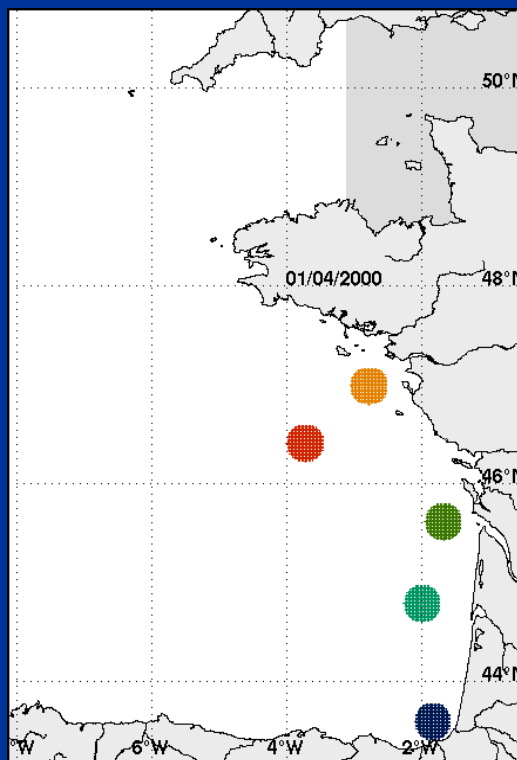


- 1D parameters (e.g. *Siegel et al. 2003*) :
 - Mean drift **distance** (d)
 - **Variance** σ
- 2D parameters (e.g. *Edwards et al. 2007*) :
 - Mean drift **direction** from starting position
 - Total variance or **Inertia** around CG
 - **Length (St. Dev.) of axis** from a PCA analysis
 - **Isotropy** between axis
 - **Orientation** of the principal axis
- 'Occupation of space' parameters (*Woillez et al. 2007*)
 - **Positive area**
 - **Equivalent area**
 - **Spreading area**
 - **Coefficient of variation**



PLD x Scenario x Spawning location x Year x Week = Set of indices

20 d Reference
 30 d Temp.
 40 d Wind.
 50 d Combine
 60 d Discharge



2000
 2001

March 1st
 March 15
 ...
 ...
 ...
 Sept. 1st

Latitude
 Longitude
 Direction
 Distance
 Inertia
 Max axis
 Min axis
 Isotropy
 Orientation
 Pos. area
 Equ. area
 Spr. area
 CV

Main drivers of the dispersal variability in the context of CC ?

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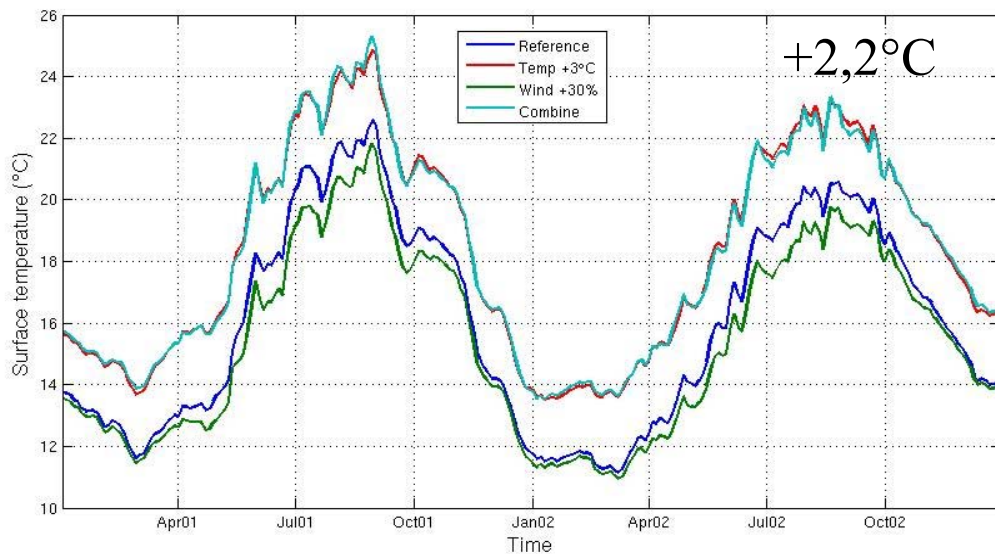
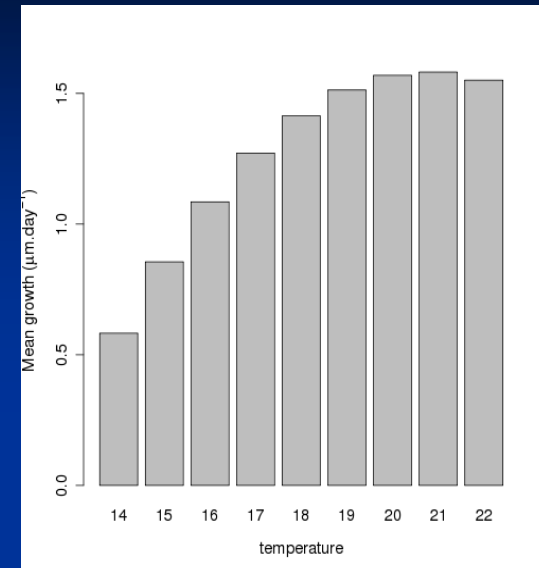
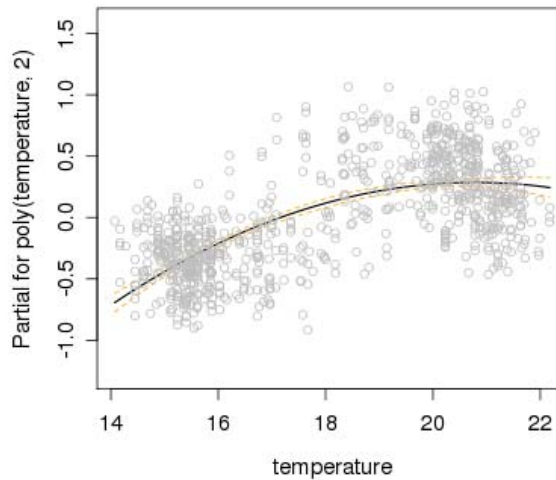
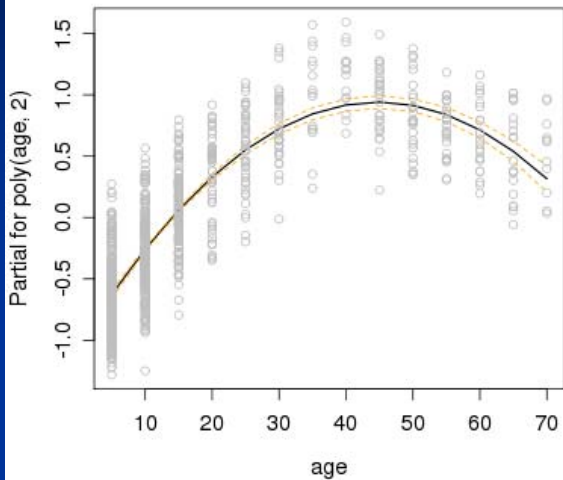
% of explained variance from MANOVA

Factor	Df	Position of the CG	Mean drift	Variance	Occupation of space	All indices
PLD	4	3,5	6,4	8,2	8,4	7,2
SCENARIO	4	2,6	6,2	1,0	1,2	2,1
SPAWNING LOC.	4	34,8	13,6	4,1	9,4	11,9
YEAR	1	0,8	0,2	3,2	3,2	2,4
WEEK	13	7,0	11,5	1,6	3,0	4,4
PLD:location	16	2,6	0,2	0,8	1,1	1,1
PLD:week	52	1,6	2,0	1,4	1,5	1,6
scenario:location	16	3,9	2,3	1,9	1,8	2,2
scenario:week	52	1,1	2,0	2,1	1,6	1,8
location:year	4	4,3	4,3	2,4	4,3	3,6
location:week	52	14,8	11,3	10,4	16,1	13,0
year:week	13	4,0	4,5	1,7	2,4	2,7
Residuals	3244	18,2	34,5	59,0	44,6	44,7

- Dispersal kernel mostly depends on :
 - spawning location
 - drift duration
- Seasonal effect important for drift distance and direction
- Drift distance is the most affected indice by tested CC scenarios.

➔ **Reduction of PLD** and **seasonal shift in spawning are** potentially important factors of change depending on the range of variation

GLM : $\ln(\text{otolith growth rate}) \sim \text{age} + \text{Temp}$

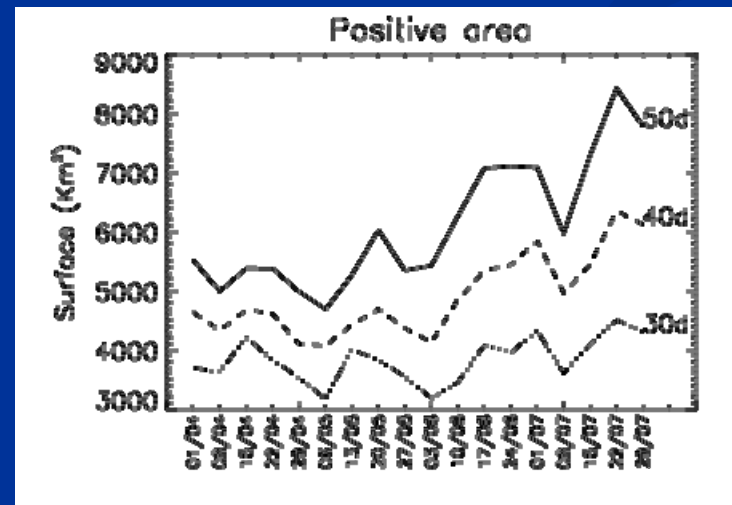
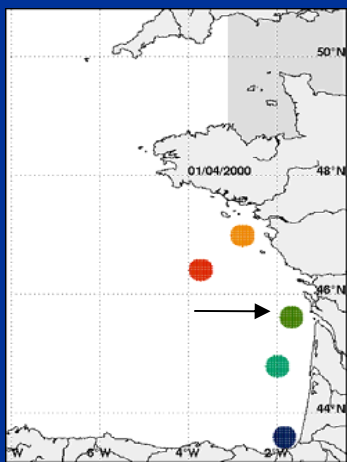
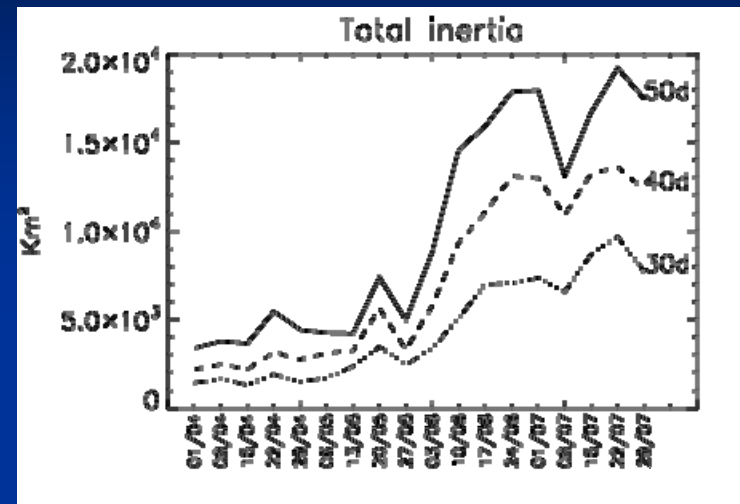
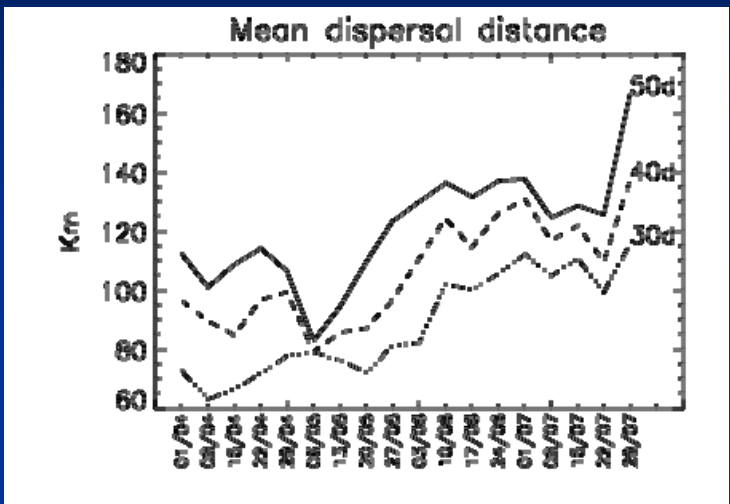


• At peak spawning, from 16°C to 18°C : **PLD -30%**

• *O'Connor et al. 2007, PNAS* : **PLD -20%**

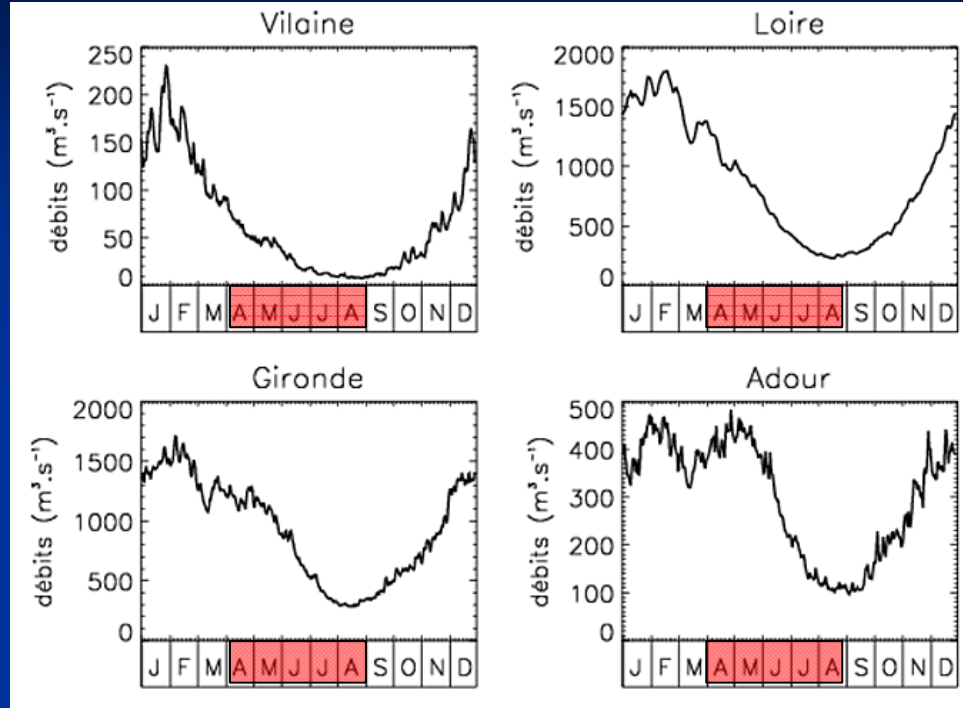
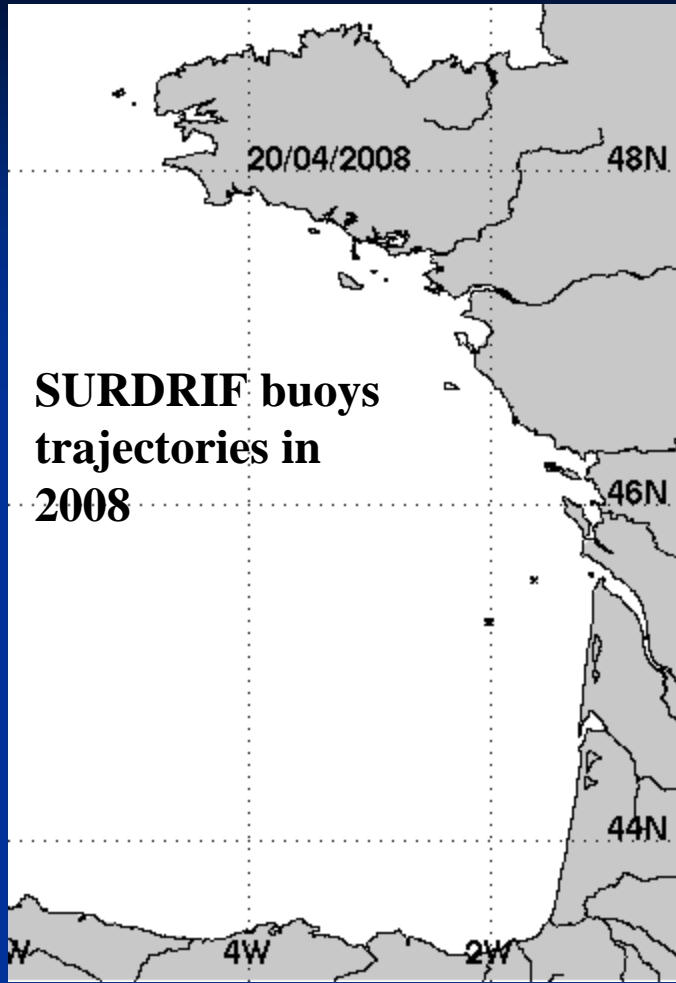
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Average value of indices over the period 1996-2007

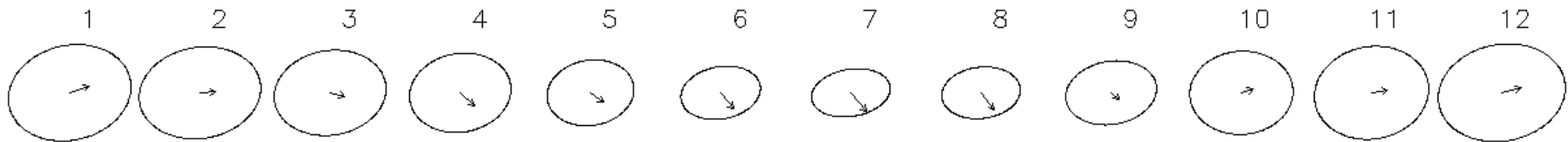


- From 50 to 35 days
- Dispersal distance = -20 %
- Inertia = -42%
- Positive area = -28%

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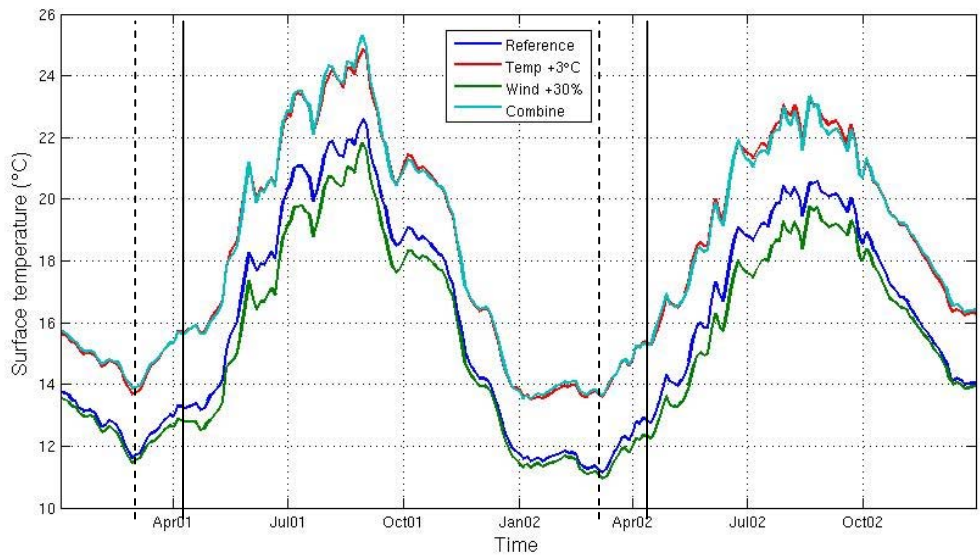
Climatology of main river run-off



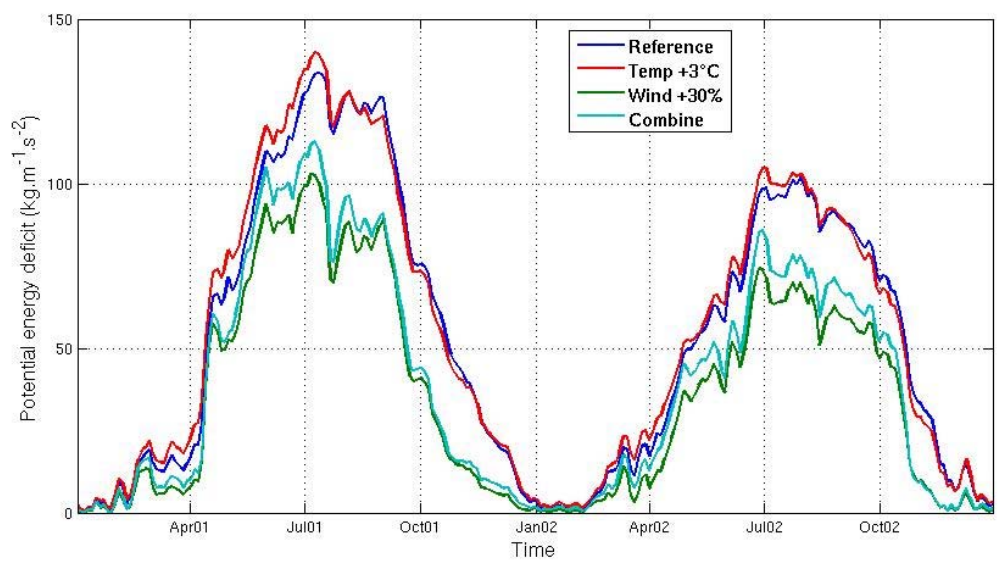
Climatology of the wind ellipses over the Bay of Biscay

Effect of a seasonal shift in spawning season (2)

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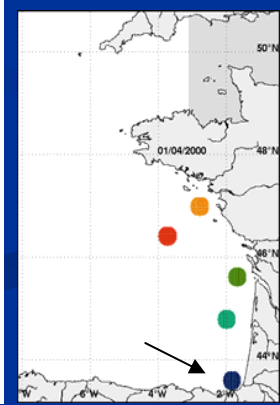
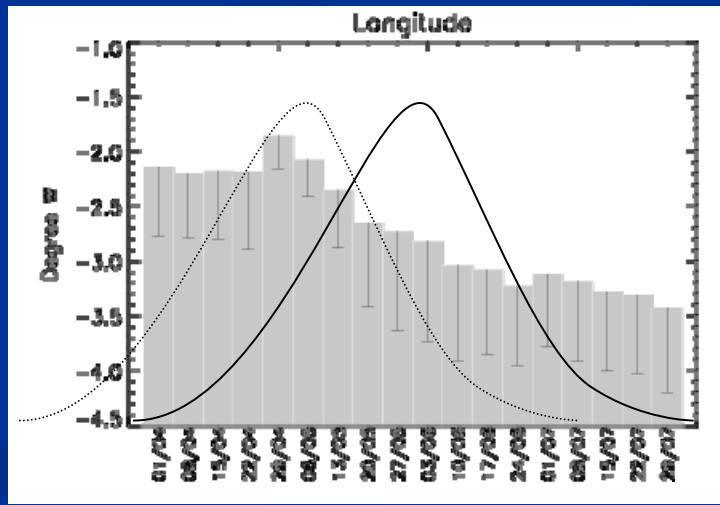
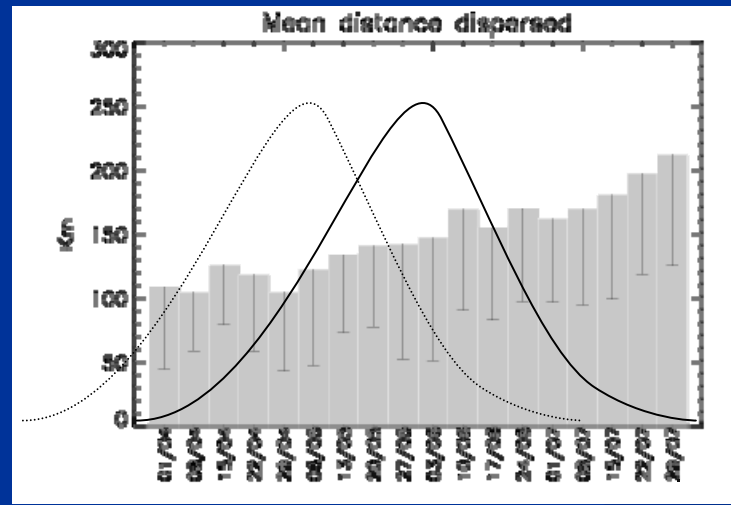
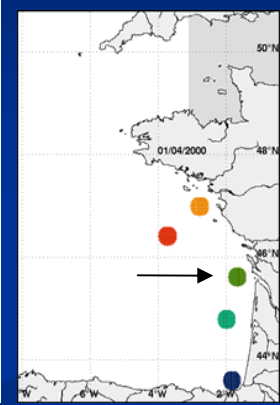
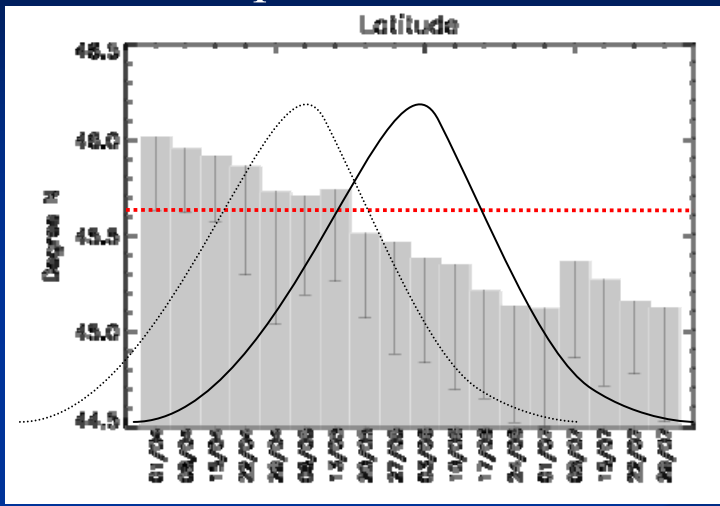
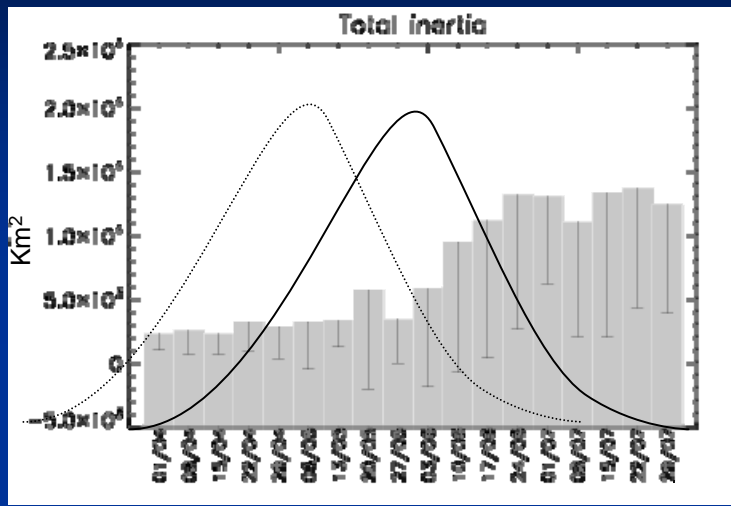


~1 month earlier



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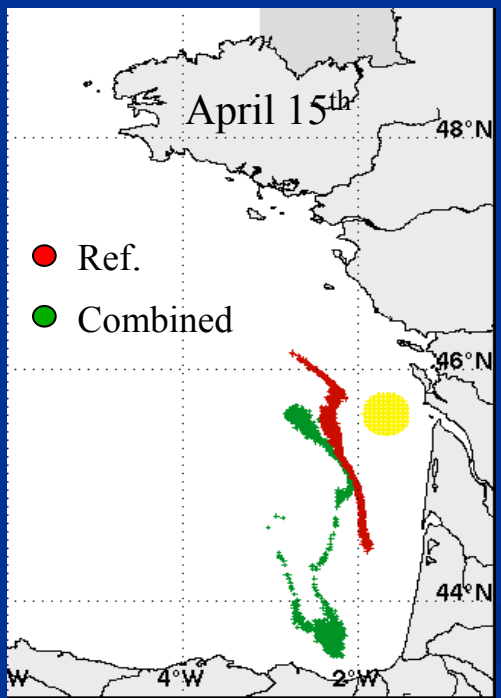
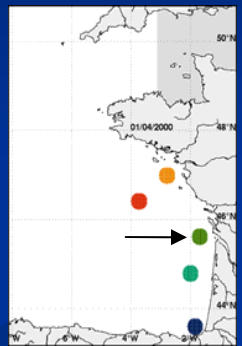
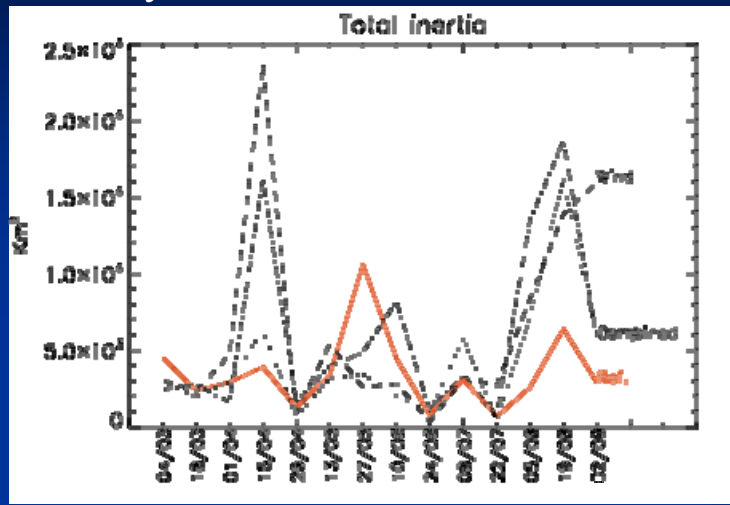
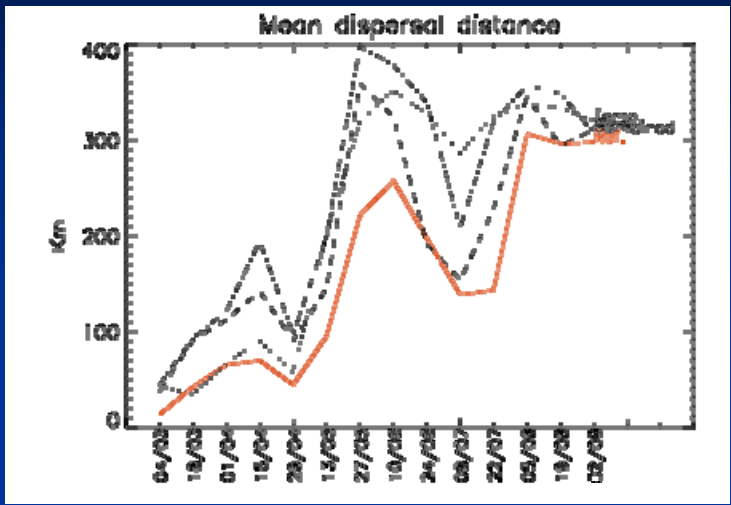
Mean and Std. deviation of indices over the period 1996 – 2007



Effect of oceanographic change through tested scenarios

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Mean values of indices over the two years of scenarios



Between Reference and Combine runs

- Dispersal distance = +58 %
- Inertia = +70%
- Positive area = +33%

Between Reference and Temp. +3°C runs

- Dispersal distance = +40 %
- Inertia = +24%
- Positive area = +13%

- Indirect and direct effects of CC have potential impacts on larval dispersal :
 - 20% reduction of PLD = more retention but reduction of connectivity (-20% dispersal distance, decrease of inertia and positive area)
 - Earlier spawning implies shift in dispersal direction for coastal spawning areas
 - Circulation pattern changes (scenario analysis) affect dispersal indices the other way round of PLD
 - Strong interaction between spawning location and seasonality. The seasonal evolution in dispersal differs among spawning locations.
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- Interaction between oceanographic change, earlier spawning and/or reduction of PLD
 - Other potential impact of CC...
 - ➔ change in spawning areas with change in hydrology.
 - ➔ Trophic aspect : food availability effect on growth rate and so on PLD.
 - ➔ Predator fields impact spatial mortality and so the observed dispersal patterns.



Thank you for your attention...

