Modeling effects of temperature and oxygen on the population dynamics of the European sturgeon:

first insight on downstream migration

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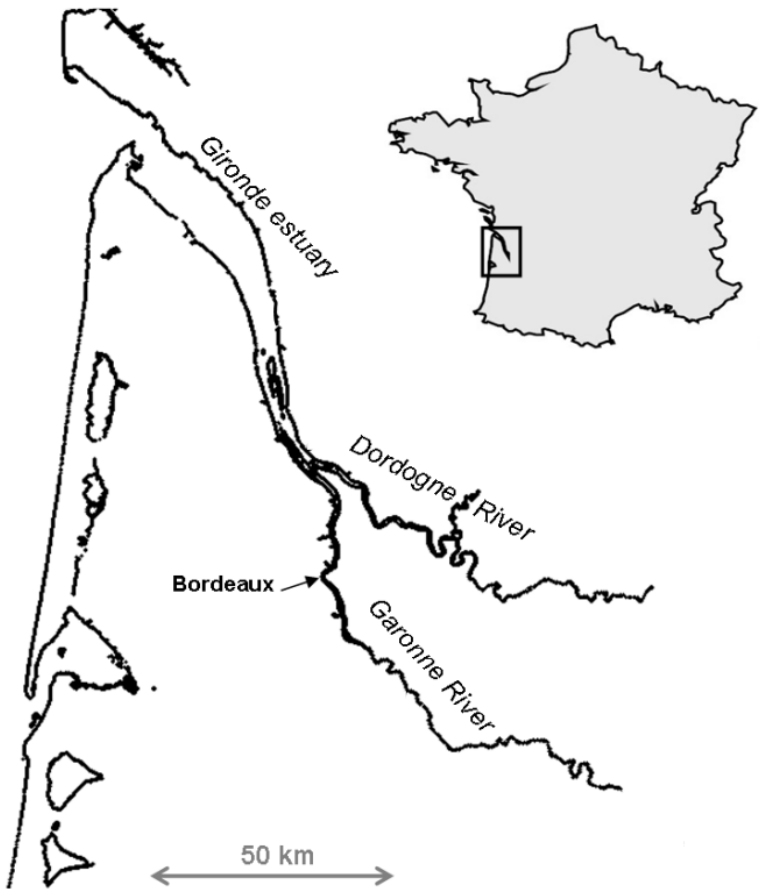
Summary

1. Introduction
2. DEB model parametrization
3. IBM: Downstream migration
4. Conclusions

Acipenser sturio

- Anadromous: Grows in salty water, reproduces in freshwater ;
- Large in size (up to 3.5 m), long life span (100 years), late reproduction (after 12 - 15 yo) ;
- Critically endangered: population collapse due to caviar industry, protected since 1982 but population did not recover yet.

Garonne-Gironde-Dordogne basin



- Two rivers which flow into one estuary which flows into the Ocean ;
- Impacted by human activities: pollution (nitrate, PCB, pesticides) hydrology (dams, agriculture) ;
- Last reproduction area of the european sturgeon (last observed in 1994) ;
- Restoration plan: assisted reproduction from a livestock located at IRSTEA's experimental station ;
- First release of larvae in 1995, regularly since 2007.

Motivations

Facts

- Increasing occurrence of hypoxic and hight temperature events
- High pollution

STURTOP project: Questions

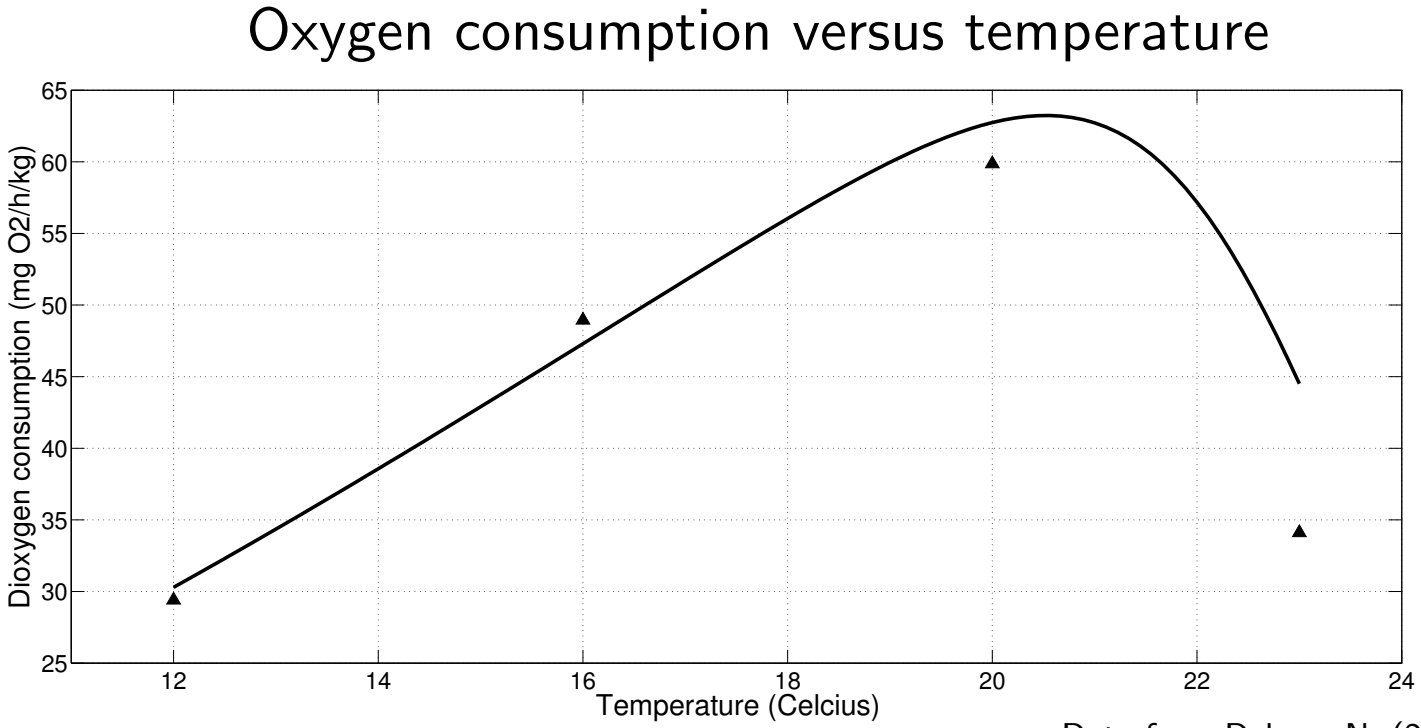
- Impact of all these stressors on early life stages (embryonic and larval)?
- Impact at population scales?

Method

- Develop a blank model representing individual sturgeon (DEB)
- Develop spatially defined IBM

Model vs. Data

Standard DEB model calibration

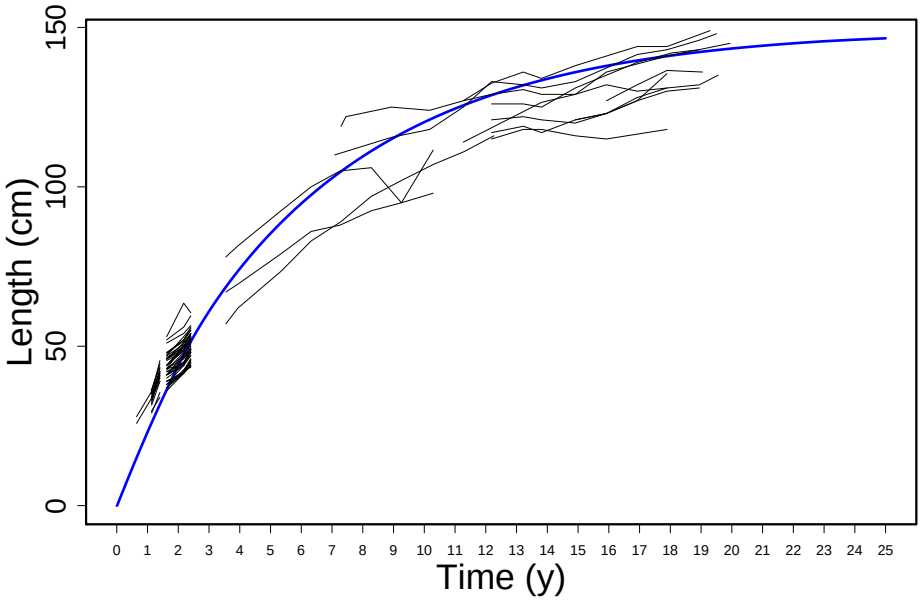


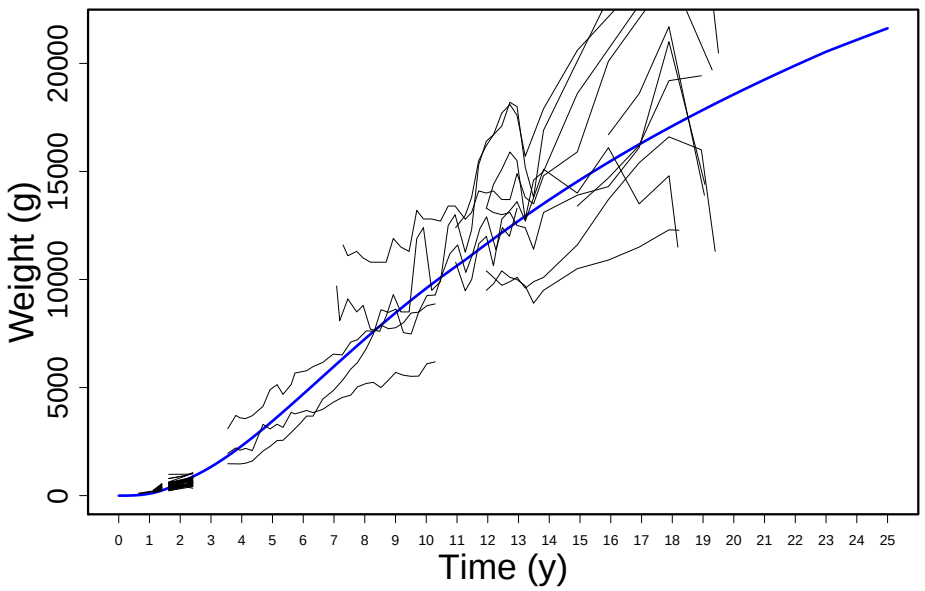
Data from Delage, N. (2015)

- Arrhenius function with decrease at boundaries
- Effects at high temperature are accounted

Standard DEB model calibration

Growth data from IRSTEA's experimental station





- We selected healthy individuals with known temperature histories
- We considered that individual were well fed up to two yo (f=1)
- After 2 yo, f=0.7 because of food quality

Standard DEB model calibration

Data (dimension)	Value	Modeled
Weight at hatching at 20 ° (g)	0.023	0.0257
Weight at birth at 20 ° (g)	0.031	0.0251
Length at hatching at 20 ° (cm)	0.93	0.63
Length at birth at 20 ° (cm)	1.65	1.5
Length at death (cm)	215	213.5
Number of egg per day ($\#/d$)	271	211
Initial amount of energy in egg (J)	159.1	118.8
Initial egg weight (g)	0.015	0.0258

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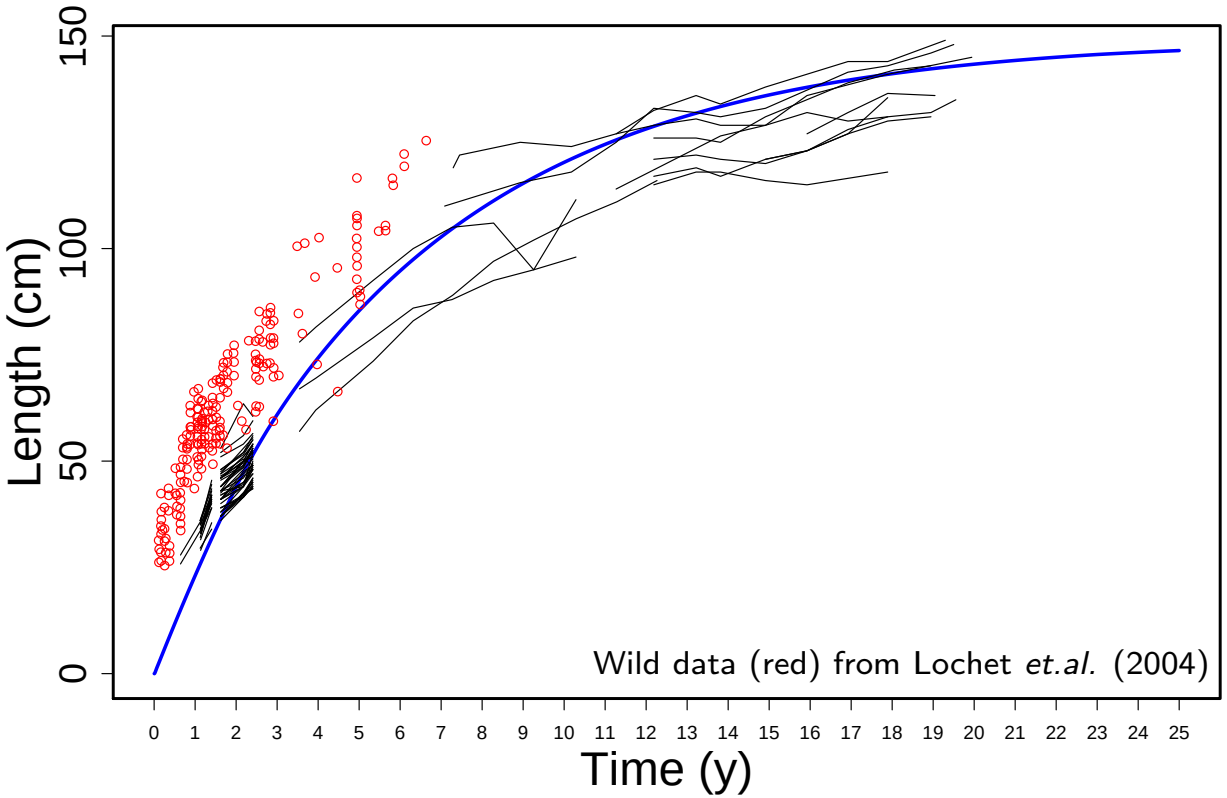
Station data vs. wild data

A size problem



- Selection of small individuals in experimental station?
- Problem of age determination?

Station data vs. wild data

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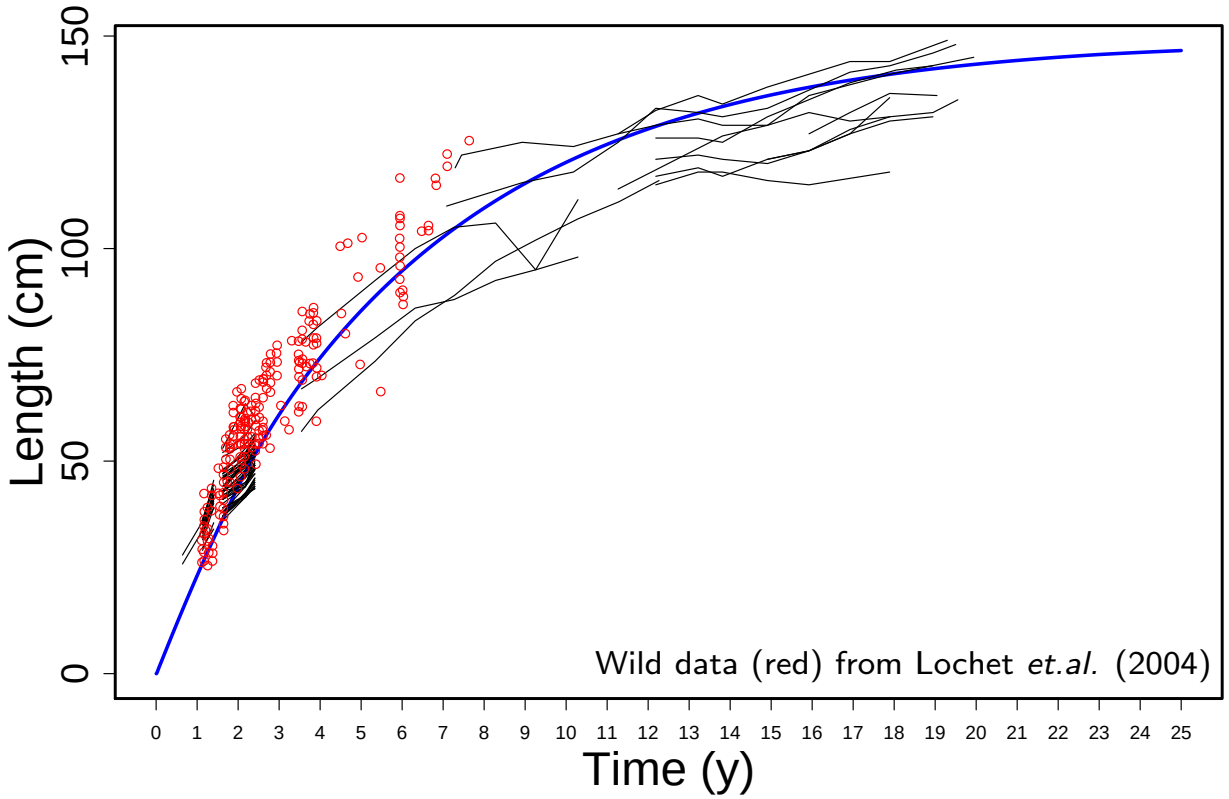

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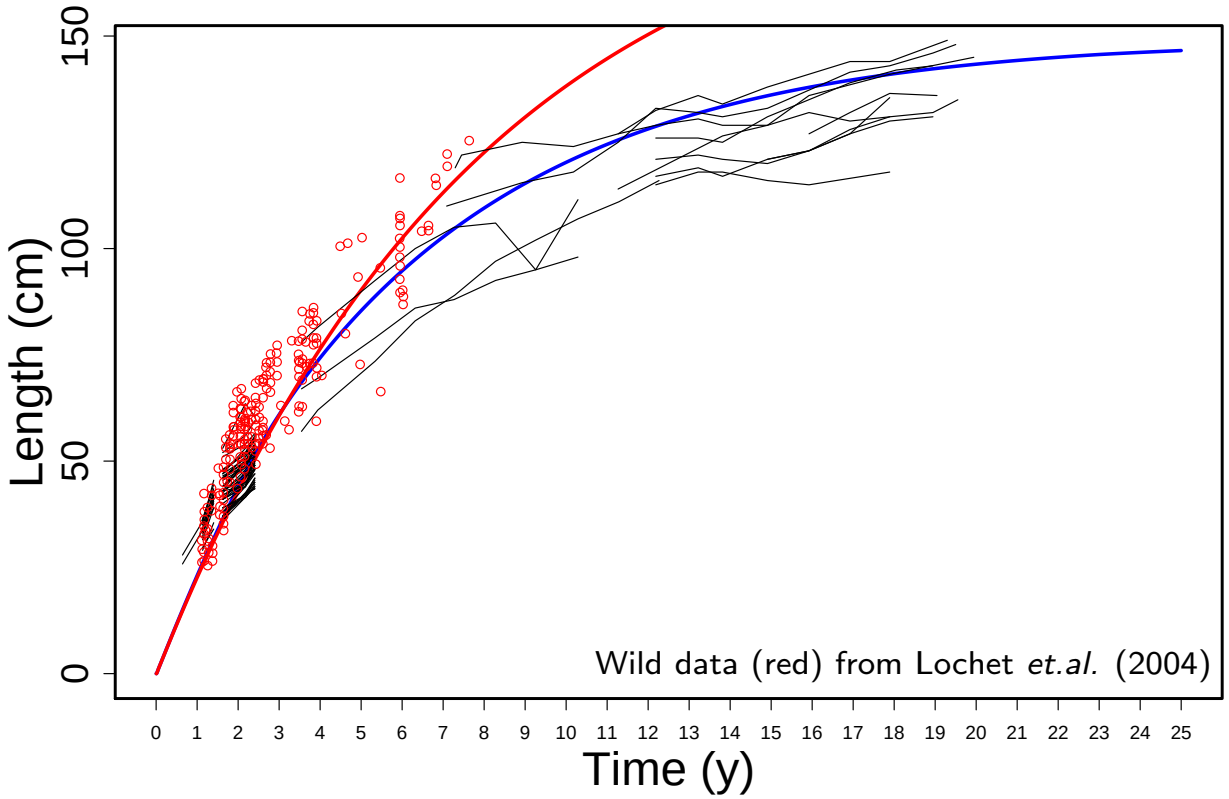

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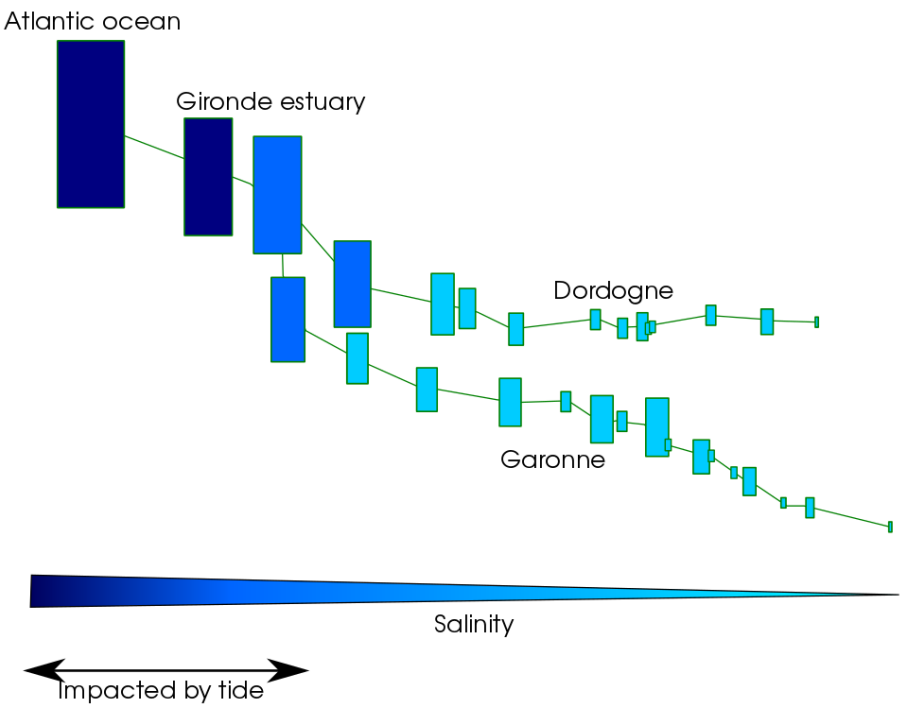
One dimensional spatially explicit model



- Distance between two cells: distance travelled in a day
- Food: logistic growth adjusted from *in situ* data
- Temperature curve from *in situ* data
- Different salinity by zones
- Different connections if zone is affected by tide or not

Downstream migration

- Driven by acquisition of osmoregulation (maturity)?
- Driven by research of food?

Decision rules

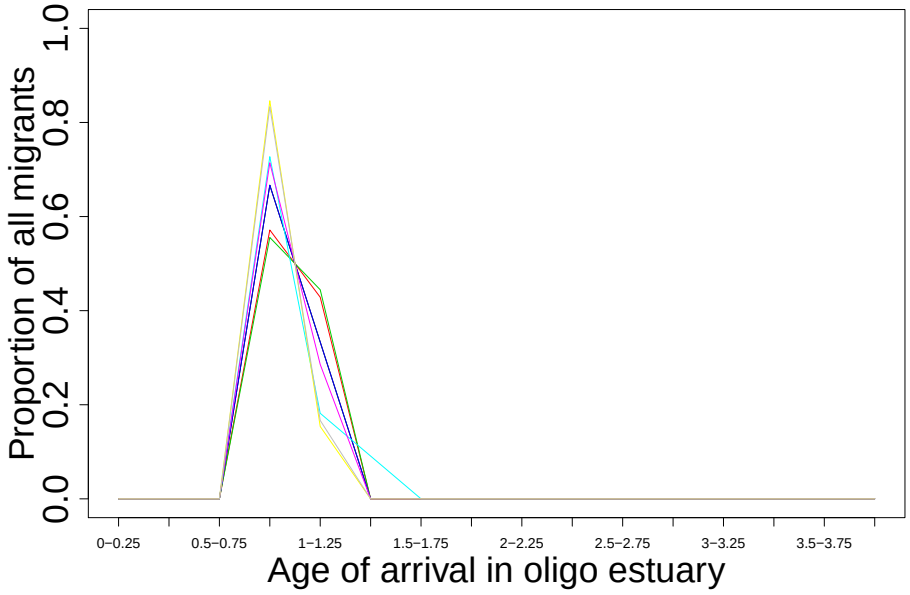
Driven by maturity

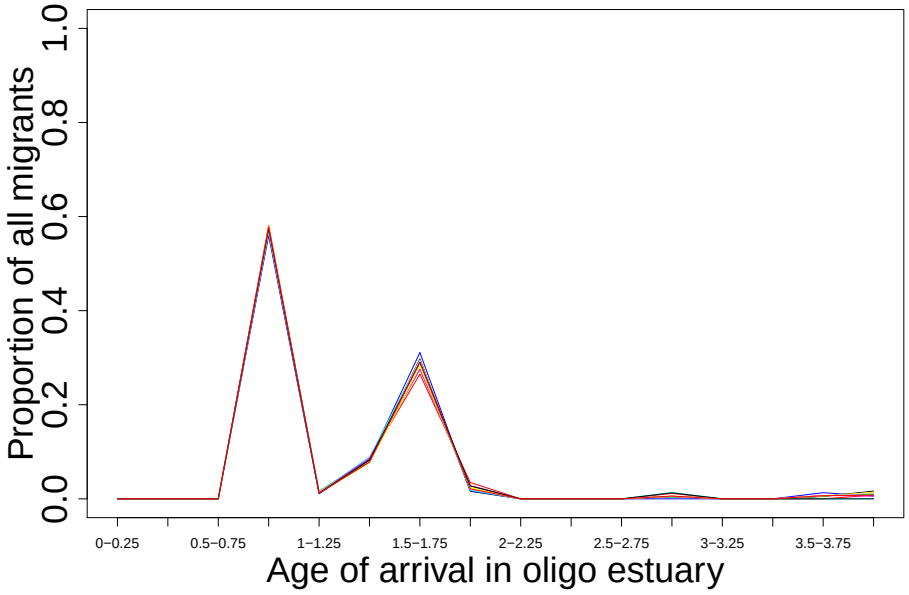
Decision rules

Driven by research of food

Decision rules

Maturity versus research of food



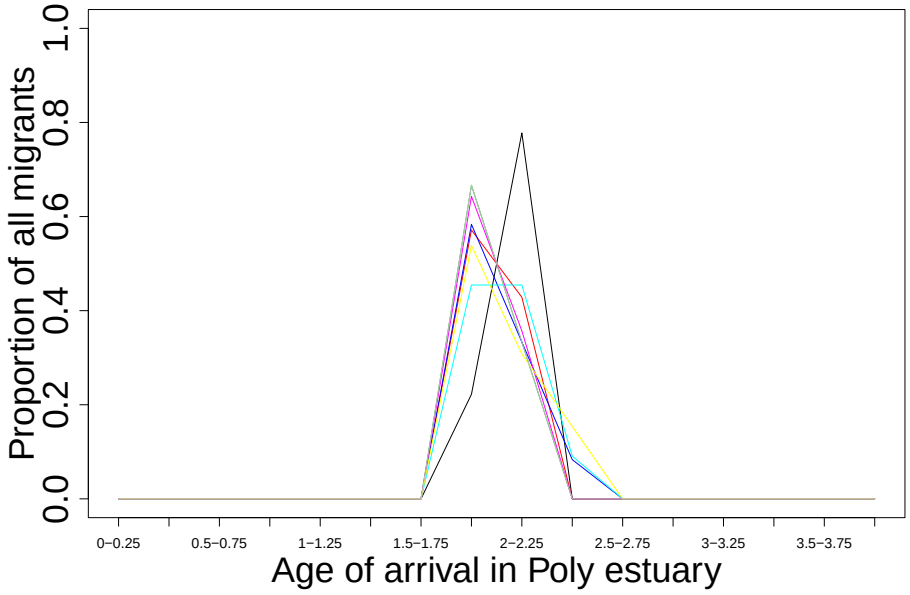


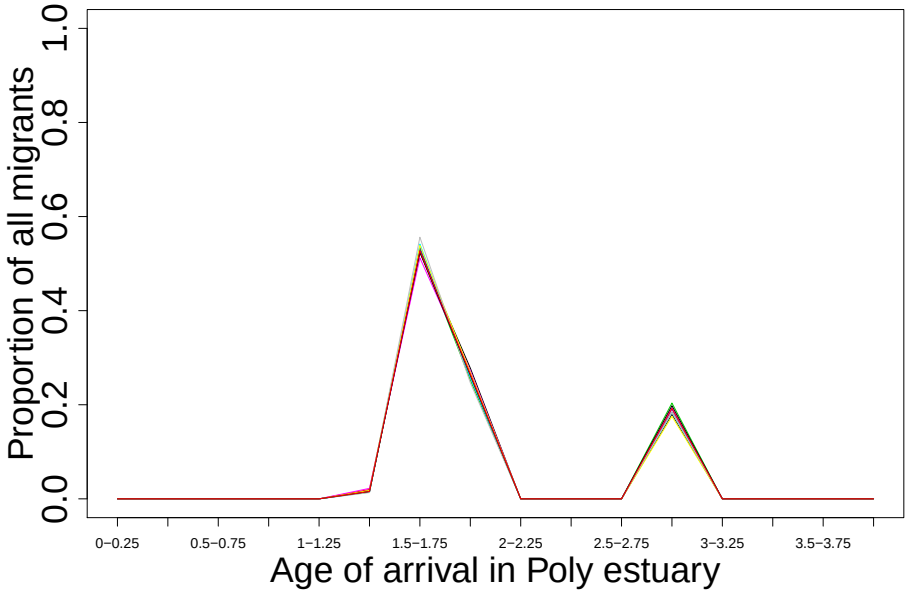
- Age (min-max): 0.9 yo (0.89 - 0.97)
- Length (min-max): 22.48 cm (22.22 - 22.87)

- Age (min-max): 1.37 yo (0.89 - 6)
- Length (min-max): 32.71 cm (22.45 - 100)

Decision rules

Maturity versus research of food



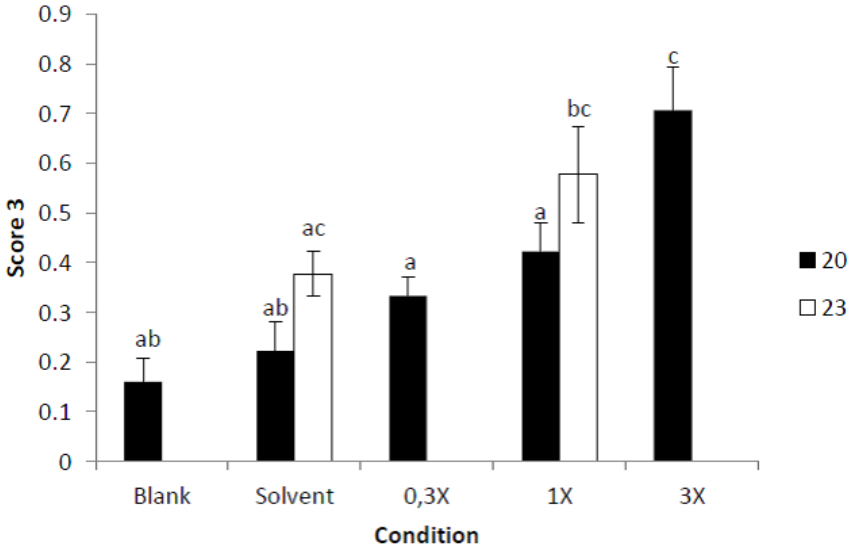


- Age (min-max): 1.9 yo (1.79- 2.04)
- Length (min-max): 43.52 cm (42.98 - 44.44)

- Age (min-max): 2.30 yo (1.30 - 4.79)
- Length (min-max): 51.2 cm (36.37 - 89.07)

Effects of stressors

Impacts of pollutants



Data from Delage, N. (2015)

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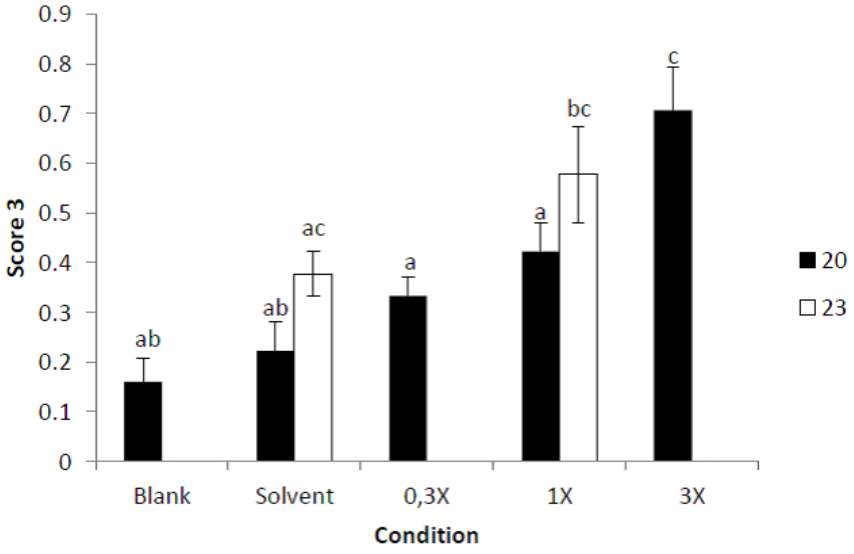

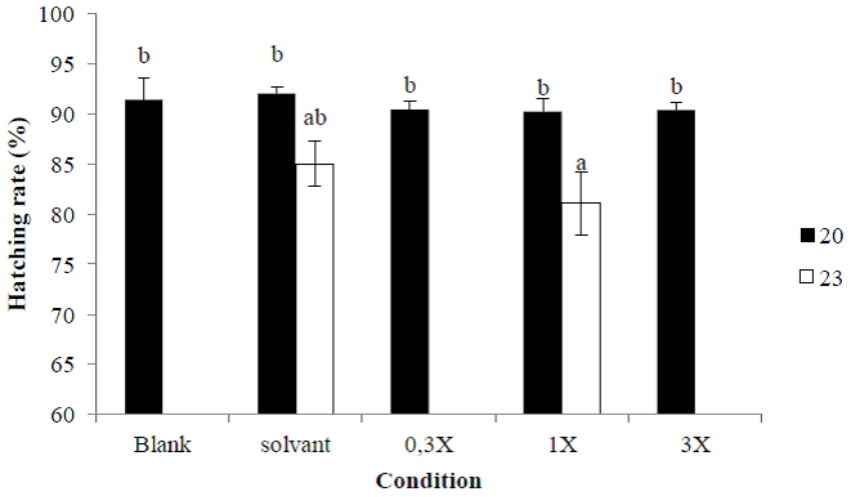

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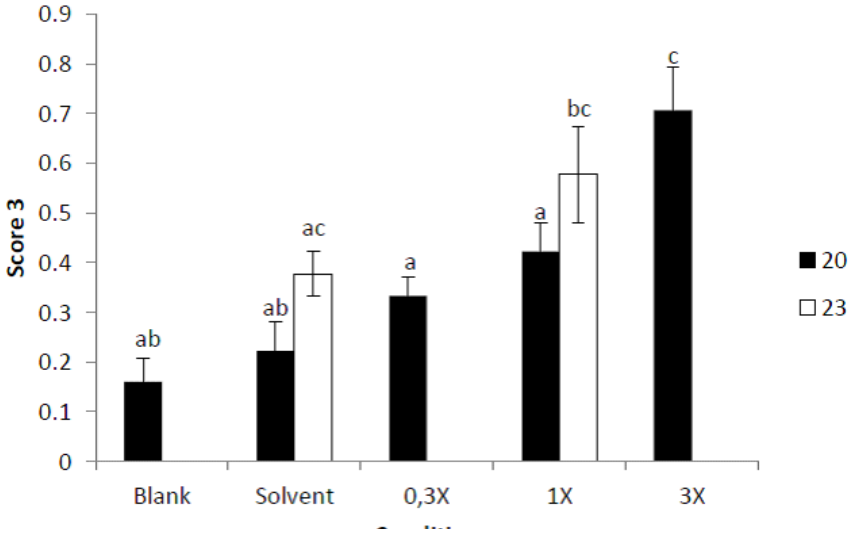

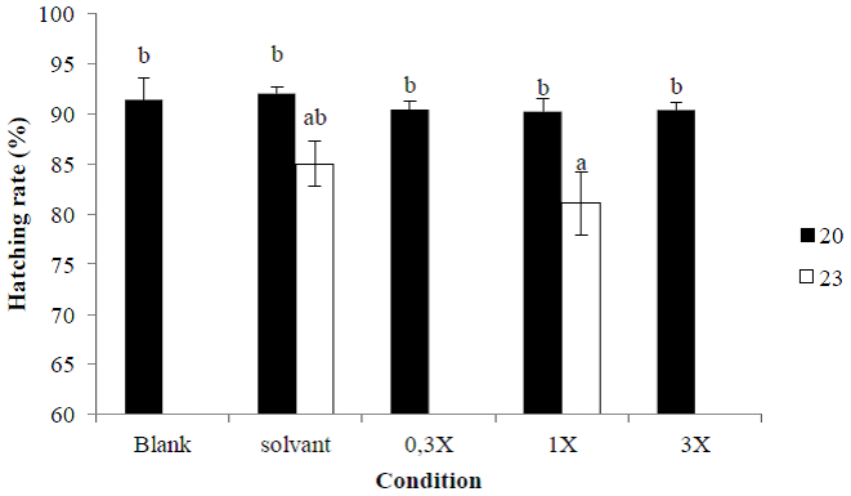

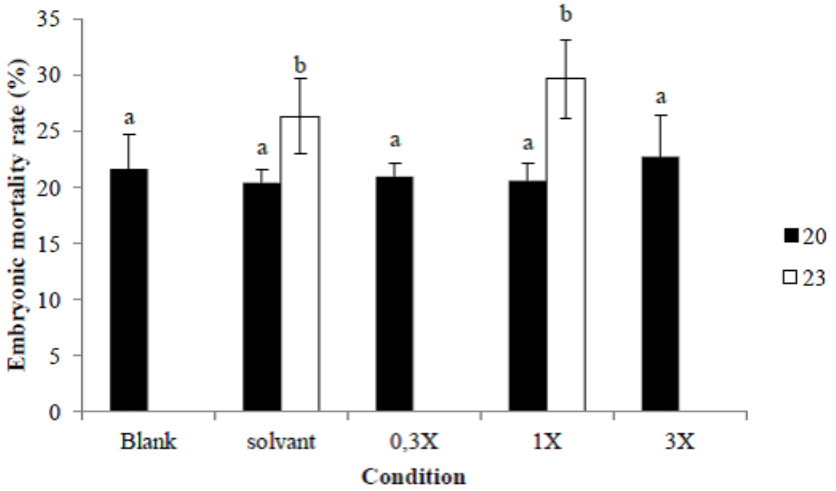

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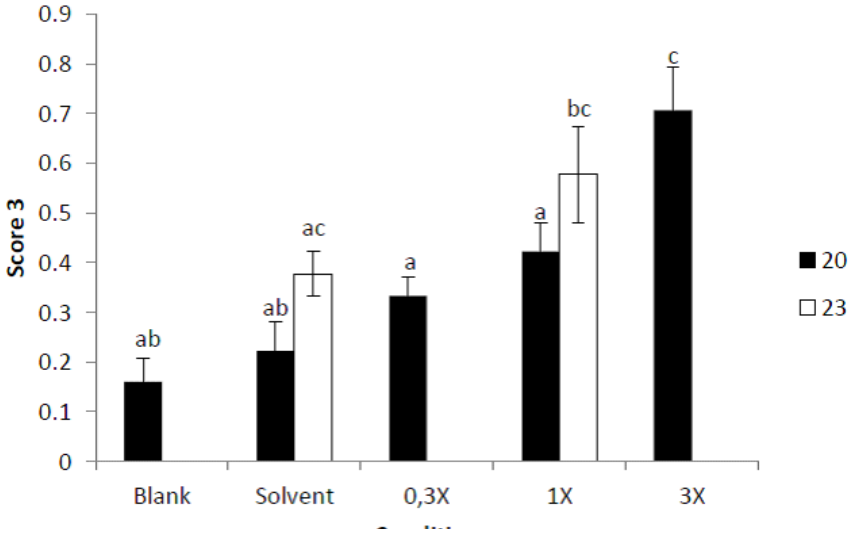

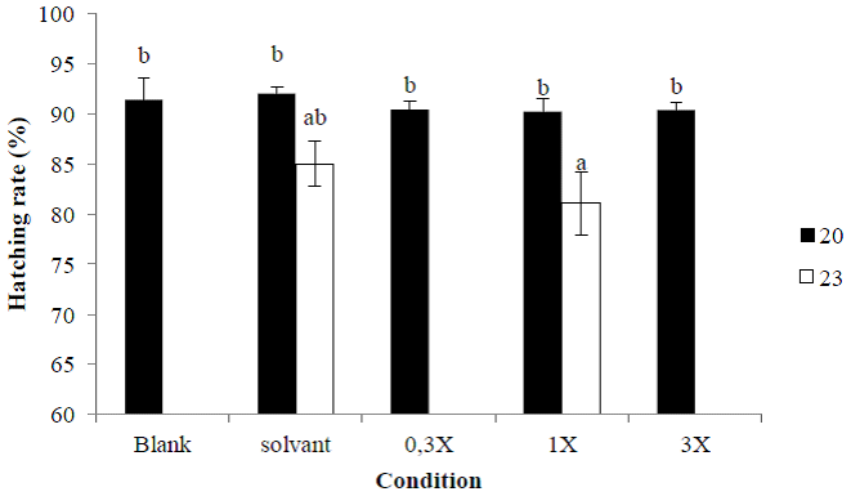

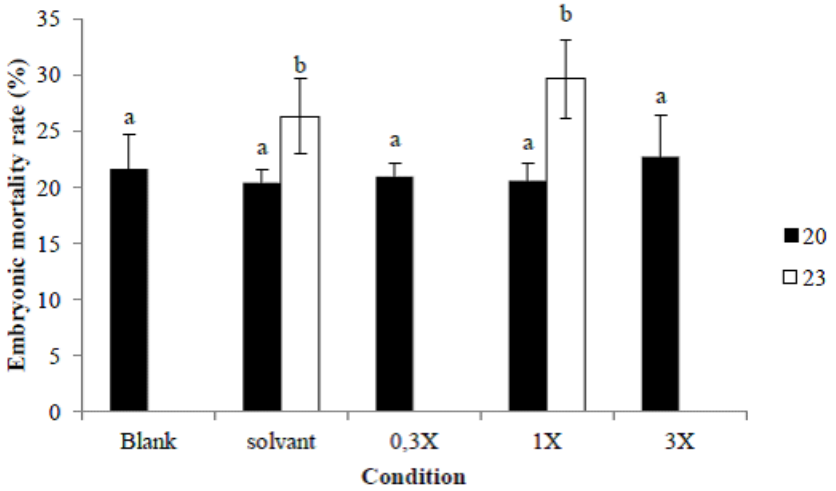

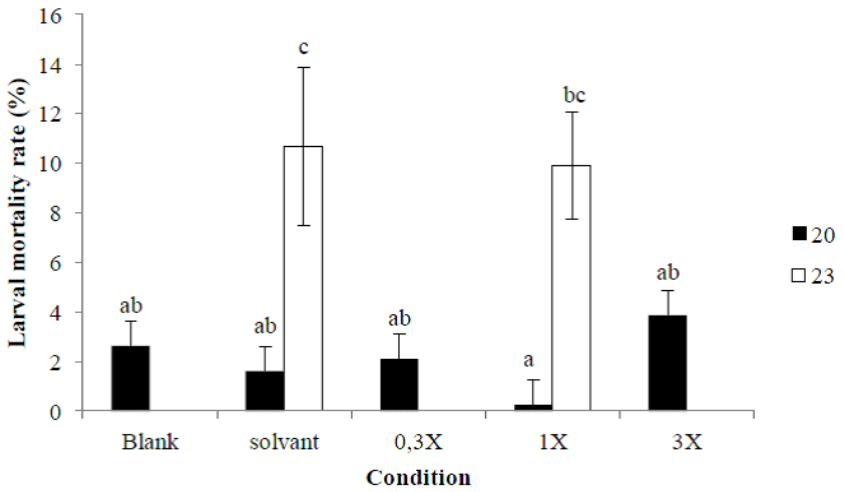

Data from Delage, N. (2015)

Consequences on arrival in oligohaline estuary

Stress factor = 0.5

Impact on age at arrival

PMoAs	Maturity	Food
Assimilation	+10 %	+ 28.5 %
Somatic Maint.	**-11.1** %	- **97.2** %
Mat. Maint.	+2.2%	-
Growth	-2.2%	+ 8.3 %

Impact on length at arrival

PMoAs	Maturity	Food
Assimilation	-1.2 %	+36.89 %
Somatic Maint.	**-4.8** %	**-96.2** %
Mat. Maint.	+1.69%	-
Growth	-8.3%	+0.4%

Same PMoA has different impact on two mechanisms in terms of nature and intensity

Conclusions

Summarizing:

- Individual reared in experimental station are possibly different from wild individual
- Two mechanisms involved in the downstream migration produce slightly different patterns
- An impact on the physiology of individual produces different changes in life traits considered the main mechanism involved

Changes in life history traits, such as length at arrival in estuary, could potentially lead to disappearance of migration!

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Changes in life history traits, such as length at arrival in estuary, could potentially lead to disappearance of migration!

Thank you for your attention!

Consequences on arrival in polyhaline estuary

Impact on age at arrival

PMoAs	Maturity	Food
Assimilation	+ 12.6 %	+ 37 %
Somatic Maint.	- **15.8** %	- **98.4** %
Mat. Maint.	- 4.7 %	-
Growth	+ 1.2 %	- 5.2 %

Impact on length at arrival

PMoA	Maturity	Food
Assimilation	- 2.8 %	+9.1 %
Somatic Maint.	- **7.2** %	- **97.4**%
Mat. Maint.	+ 3.2 %	-
Growth	-5.7 %	- 2.2 %