AMEDEE

21 octobre 2019, Nantes

Retracer les variations spatio-temporelles de la croissance en mer des salmonidés à l'aide des collections historiques d'écailles

Cécile TREHIN

Thèse 2018-2021

UMR ESE - Ecologie et Santé des Ecosystèmes

Equipe CREA - Conservation et Restauration des Ecosystèmes Aquatiques

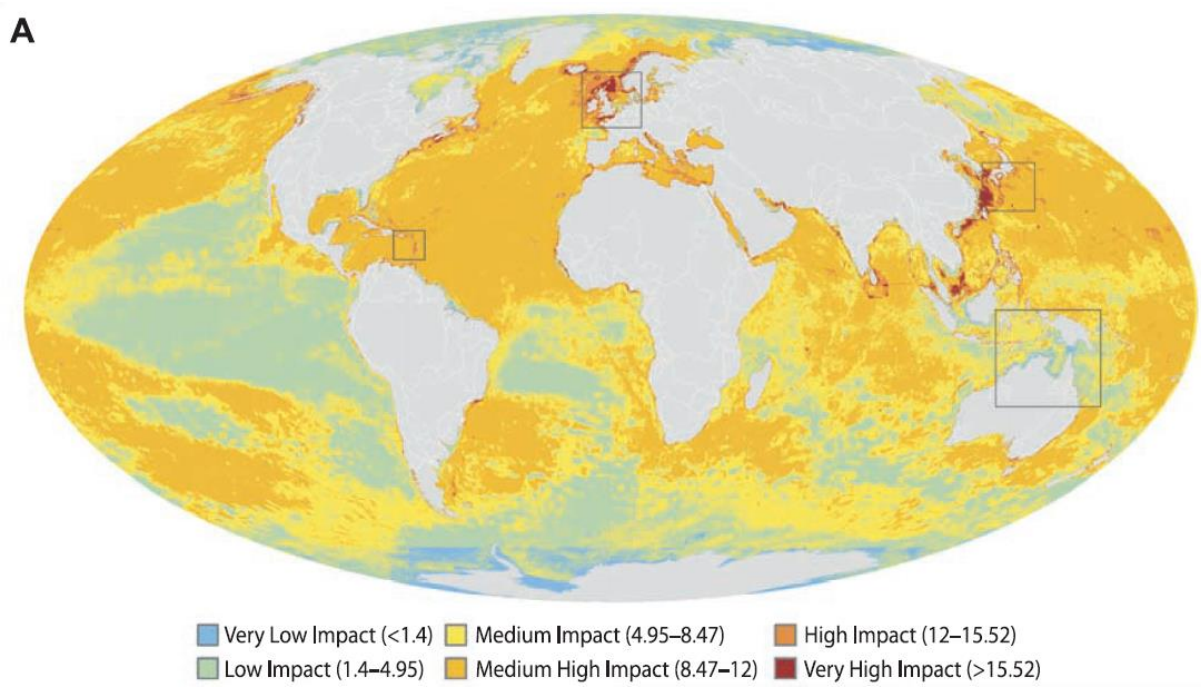
Encadrants: Guillaume EVANNO, Marie NEVOUX, Etienne RIVOT

Introduction: Context

Marine environment under multiple pressures:

- Overharvesting
- Habitat loss
- Climate change

Cumulative impacts of human activities on marine ecosystems



Halpern *et* al, 2008

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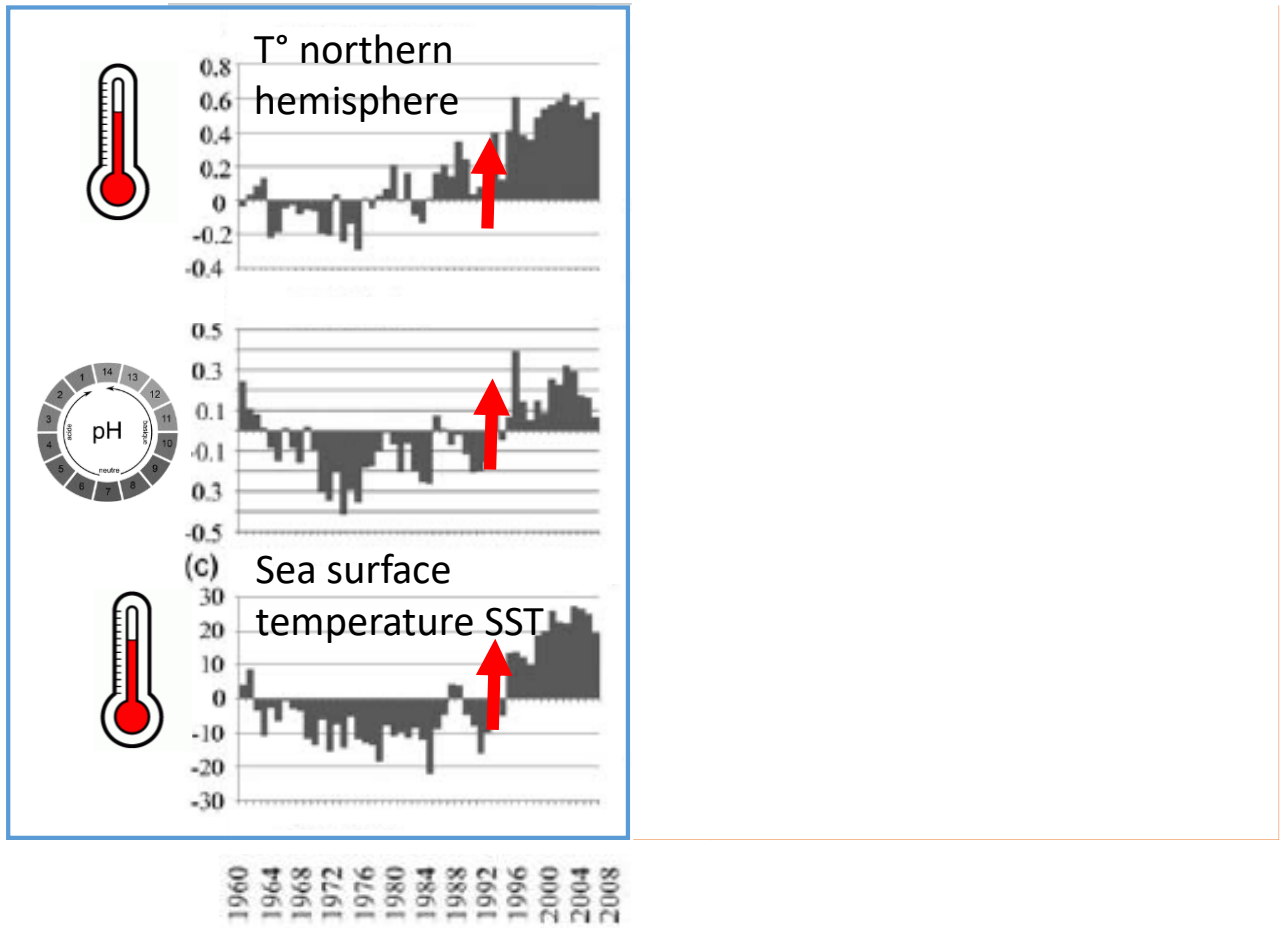
- **Climate change**
  - → **Abiotic** and biotic changes

« Shift » in the pelagic food web in the 90s



Beaugrand *et* al, 2012

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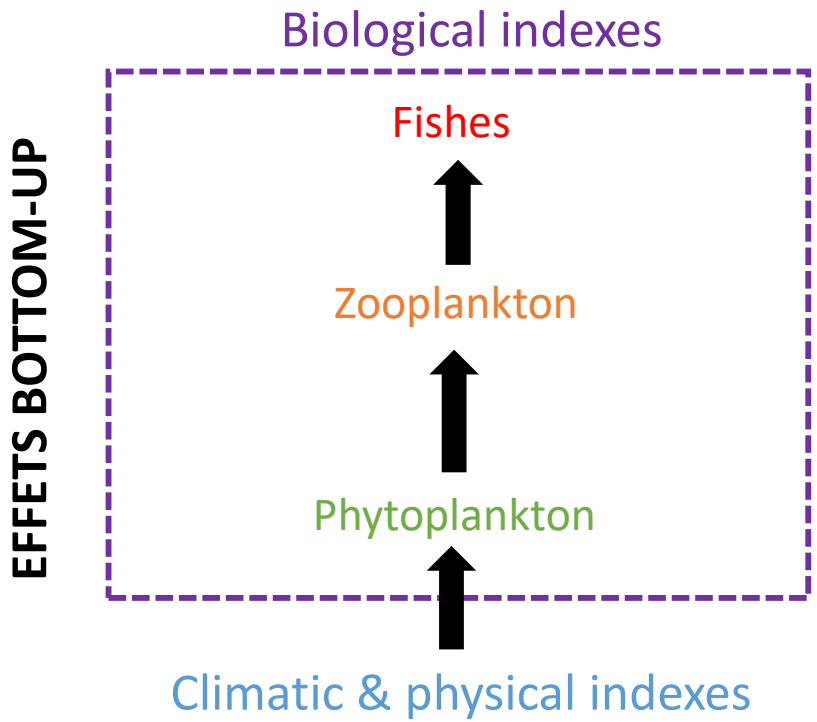

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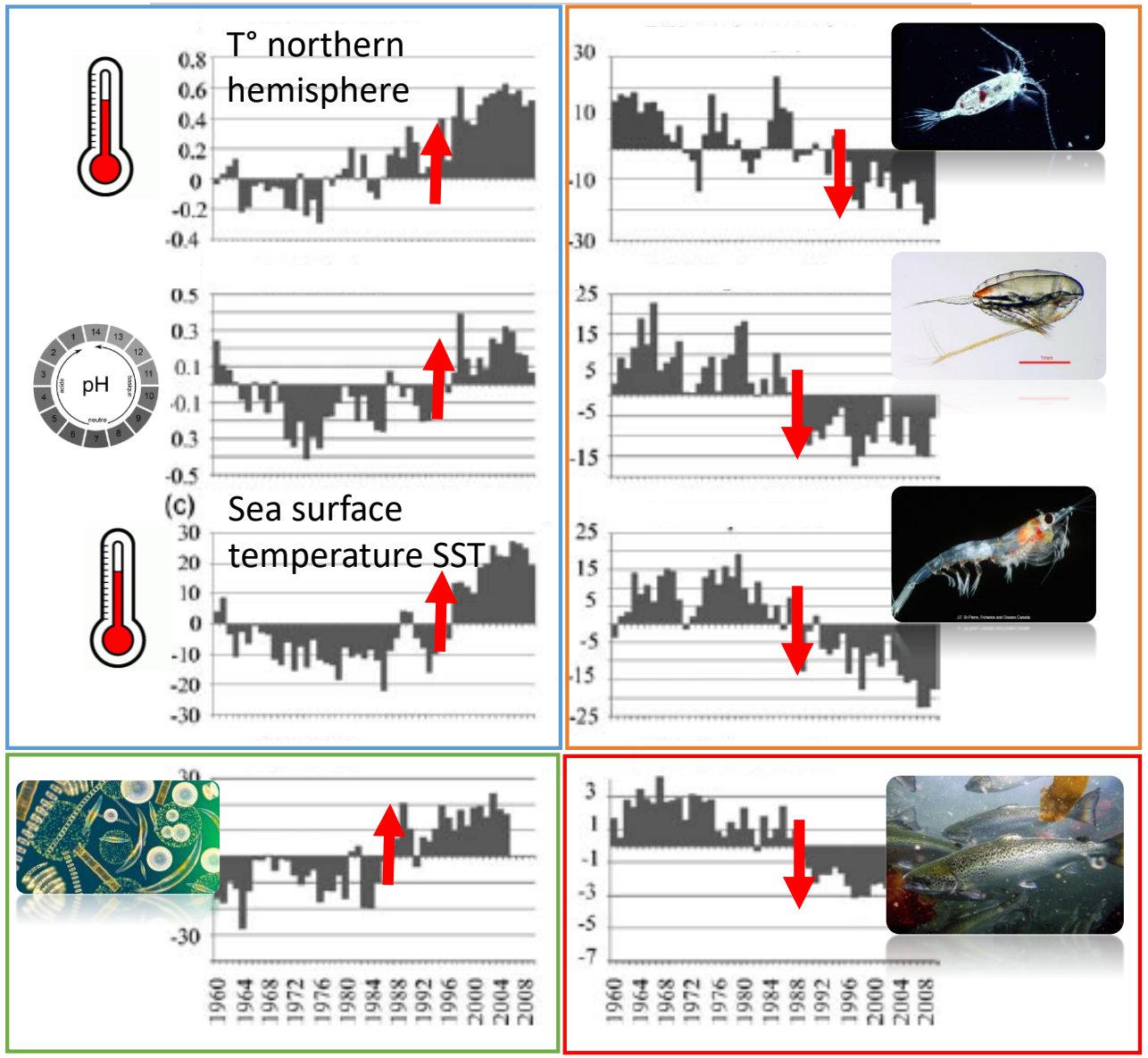

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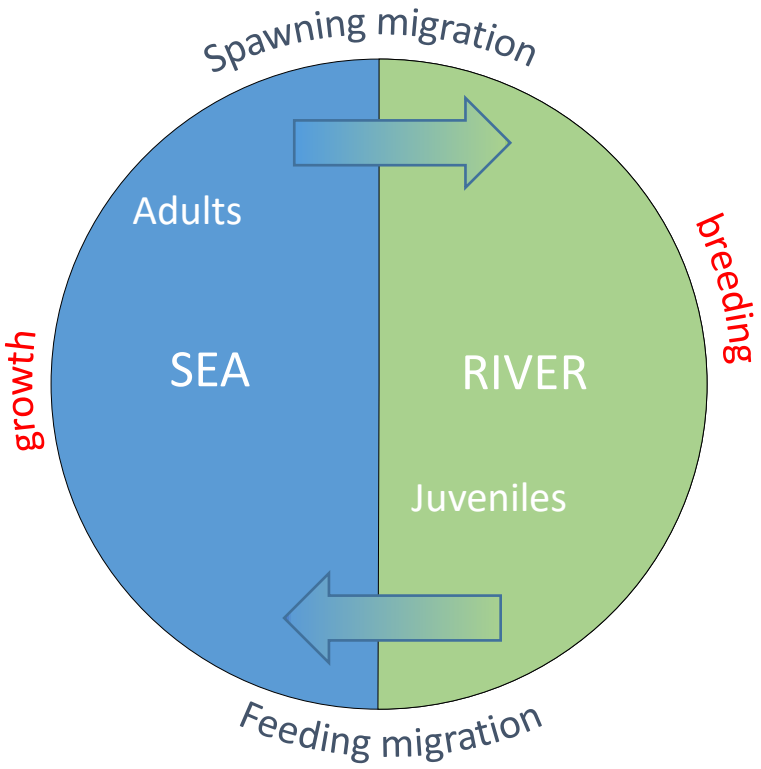
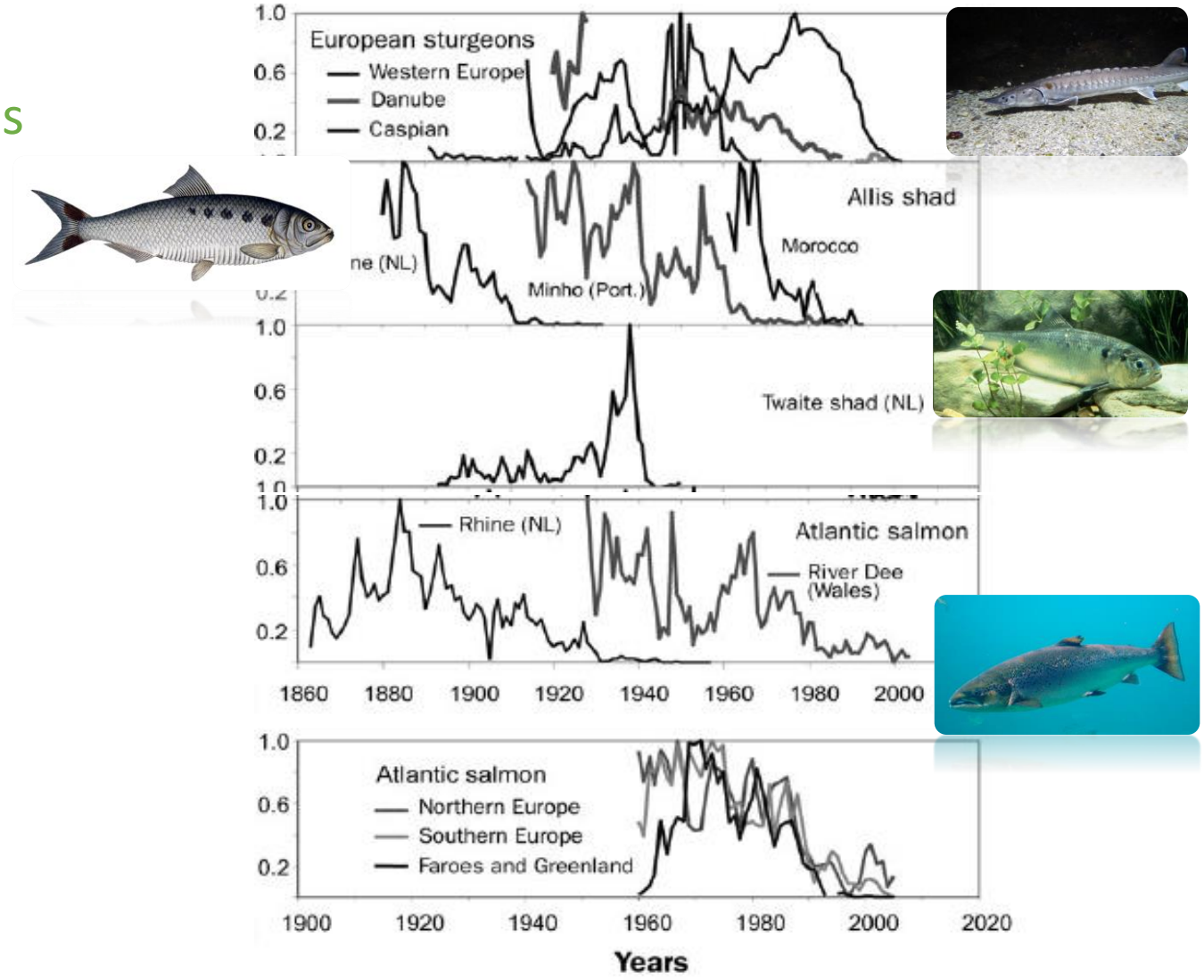
- Since the 1970s

Unexplained global decline of anadromous fish populations



Life cycle of anadromous fishes

Decline in abundance of different species of anadromous fish in Northern Atlantic



Limburg & Waldman 2009

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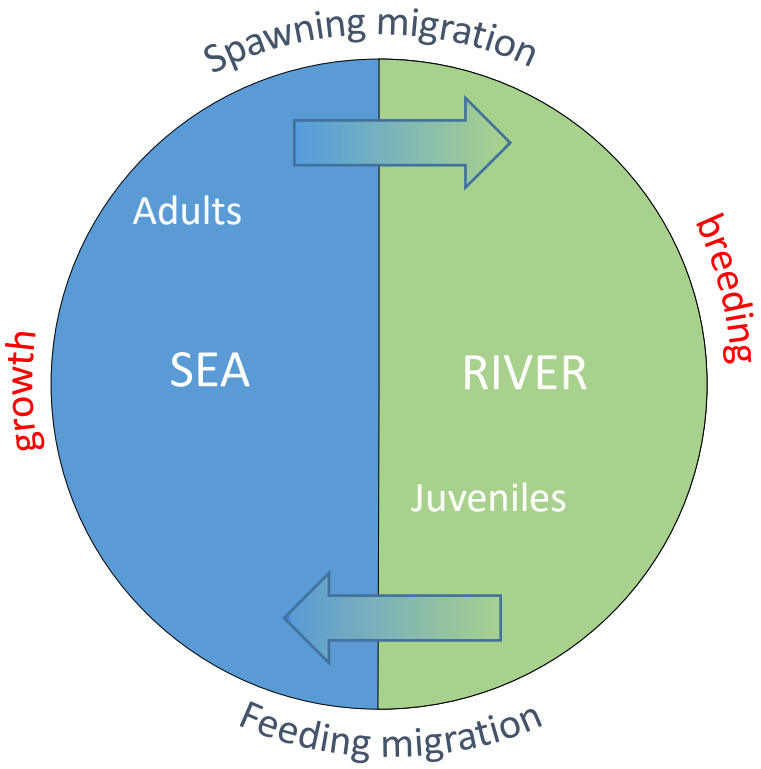

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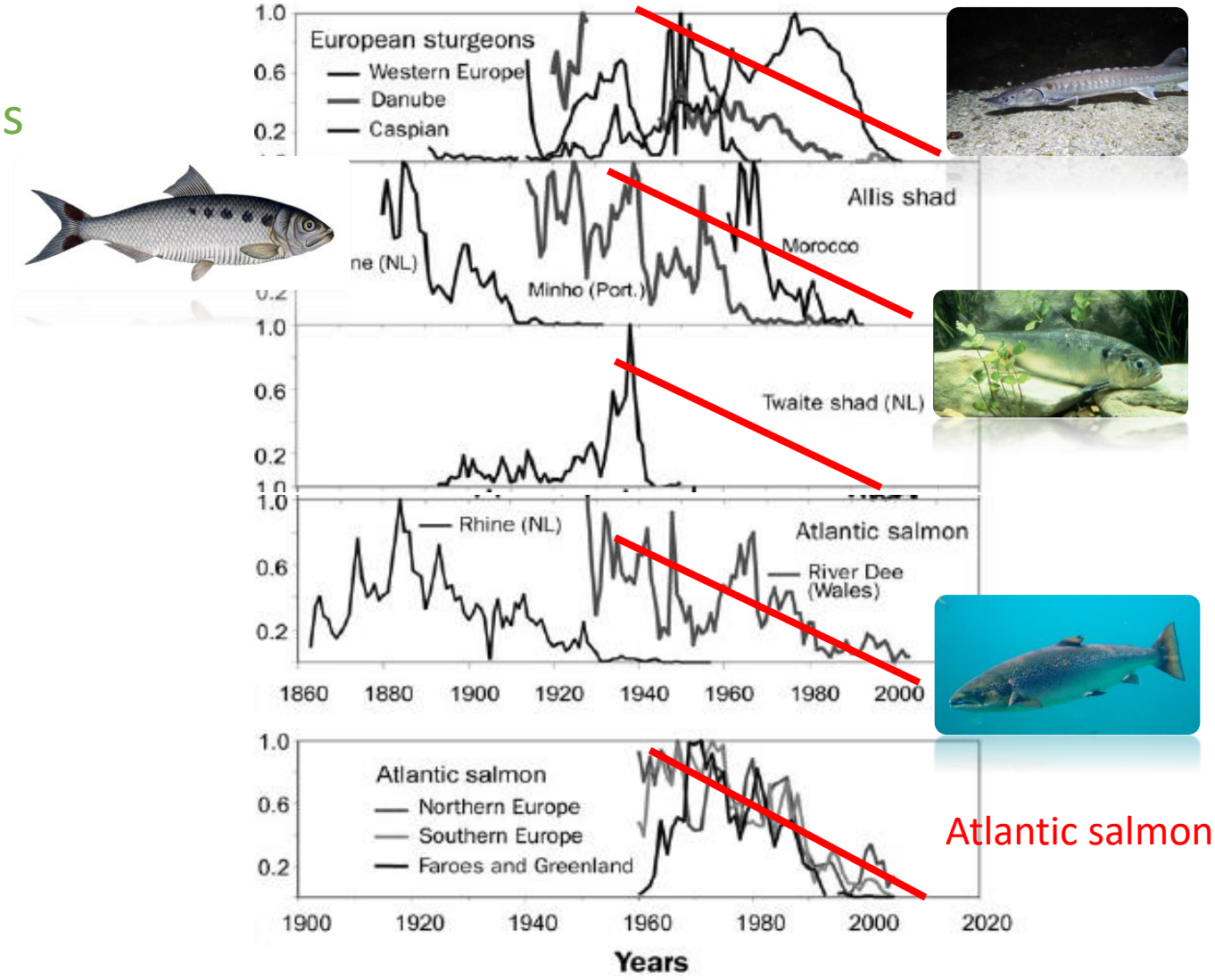

Atlantic salmon

Limburg & Waldman 2009

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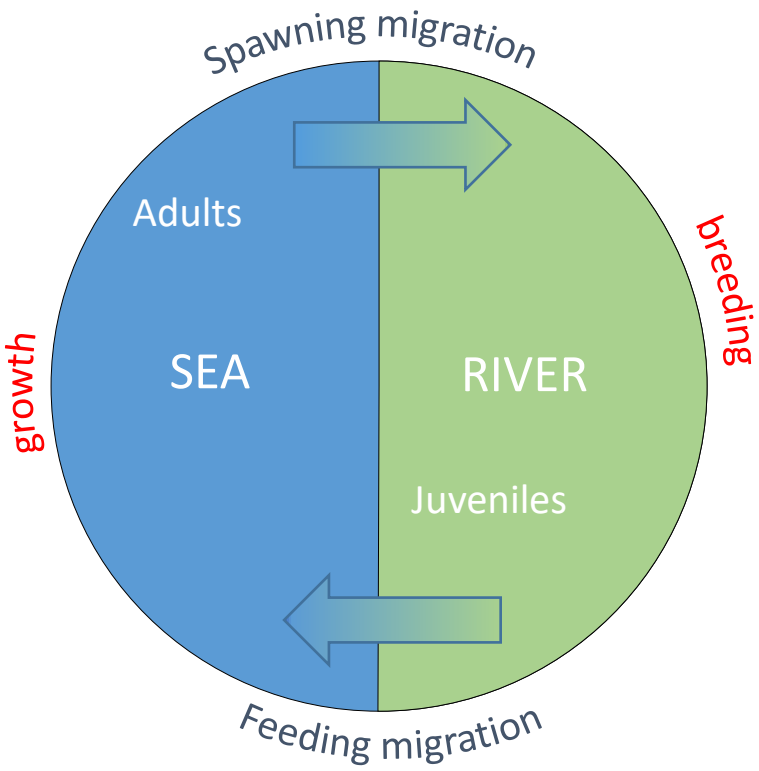


Life cycle of anadromous fishes

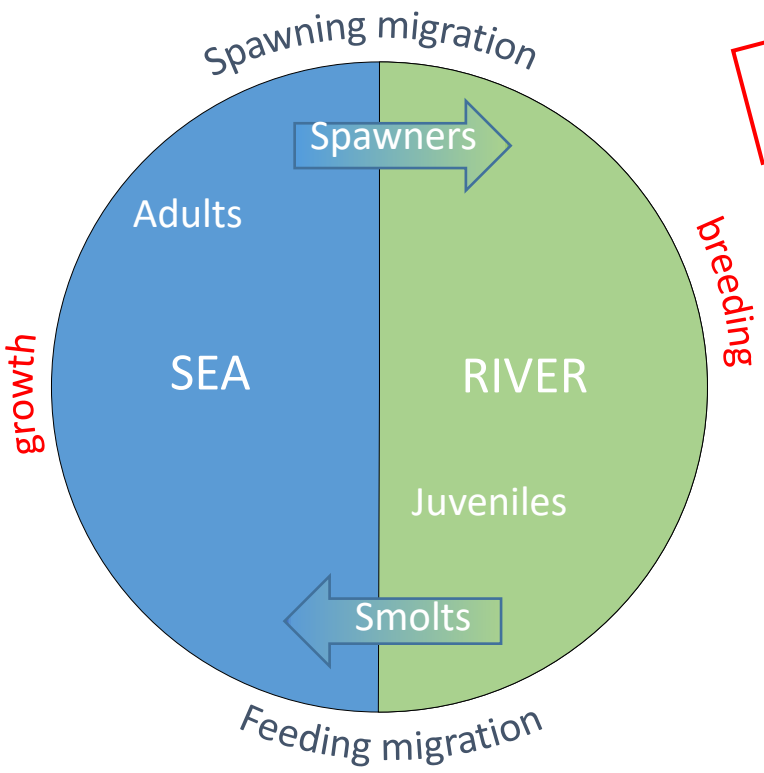
- Complexity of the population structure
- Harvested Species
- Emblematic species
- Indicators of water quality

Ecological and **management** challenges

To understand the declines

Atlantic salmon:

A life cycle shaped by migrations

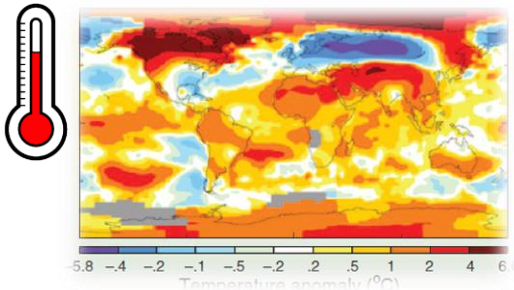


Sensitives to multiples pressures at different **spatial** and **temporal** scales:

- In river
- At sea

➔ At different life cycle stages.

Cumulative effects



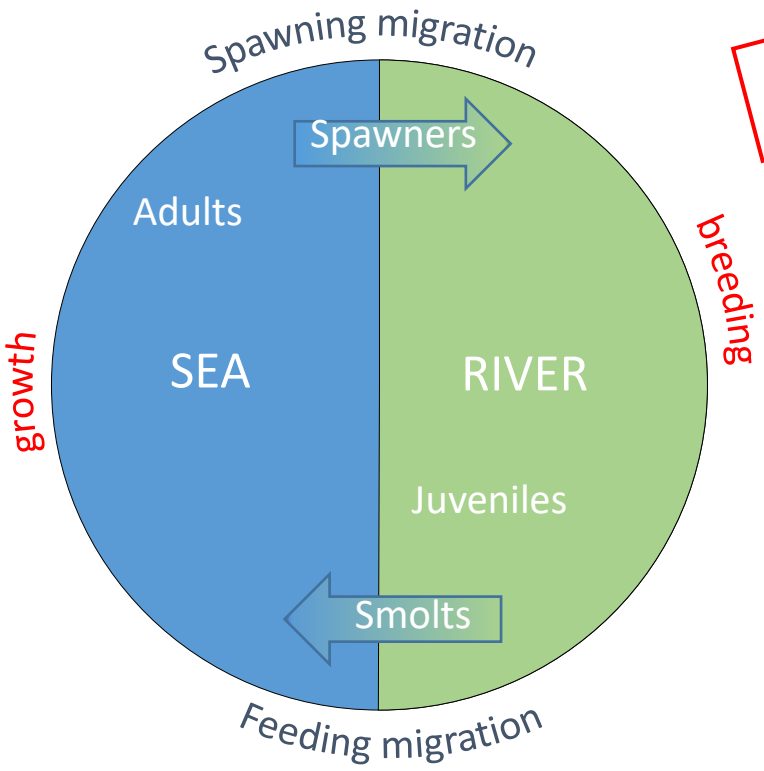
LOCAL → GLOBAL

SPECIFIC PRESSURES
Spatial segregation of populations

COMMON PRESSURES
Common feeding grounds

Atlantic salmon:

A life cycle shaped by migrations



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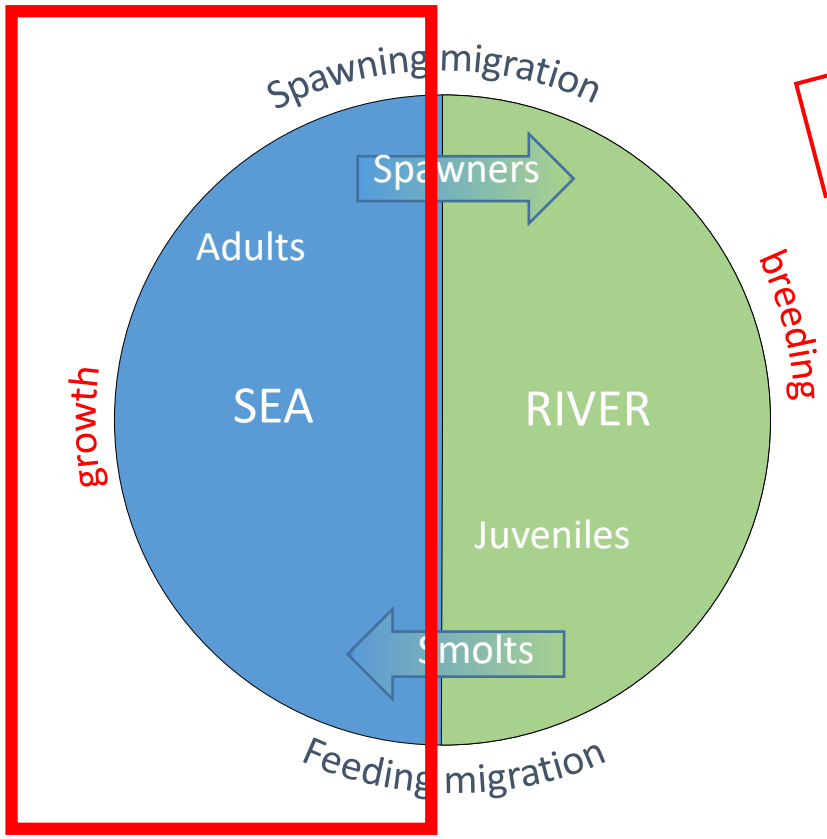

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➔ Contribution of marine phase ?

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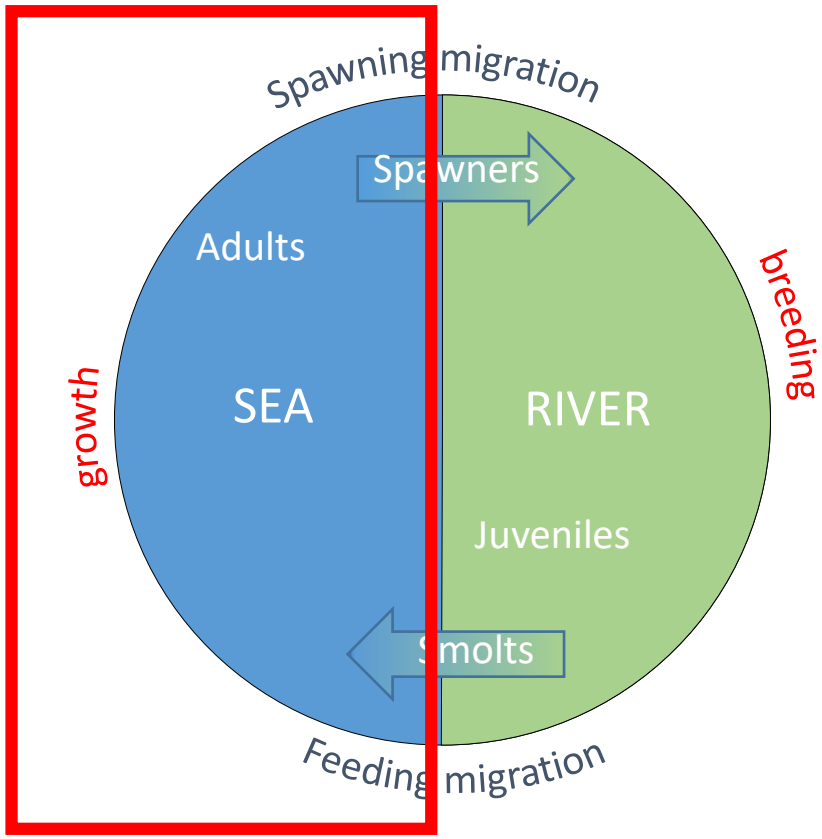
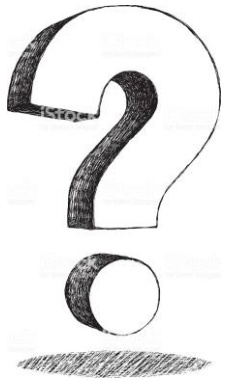




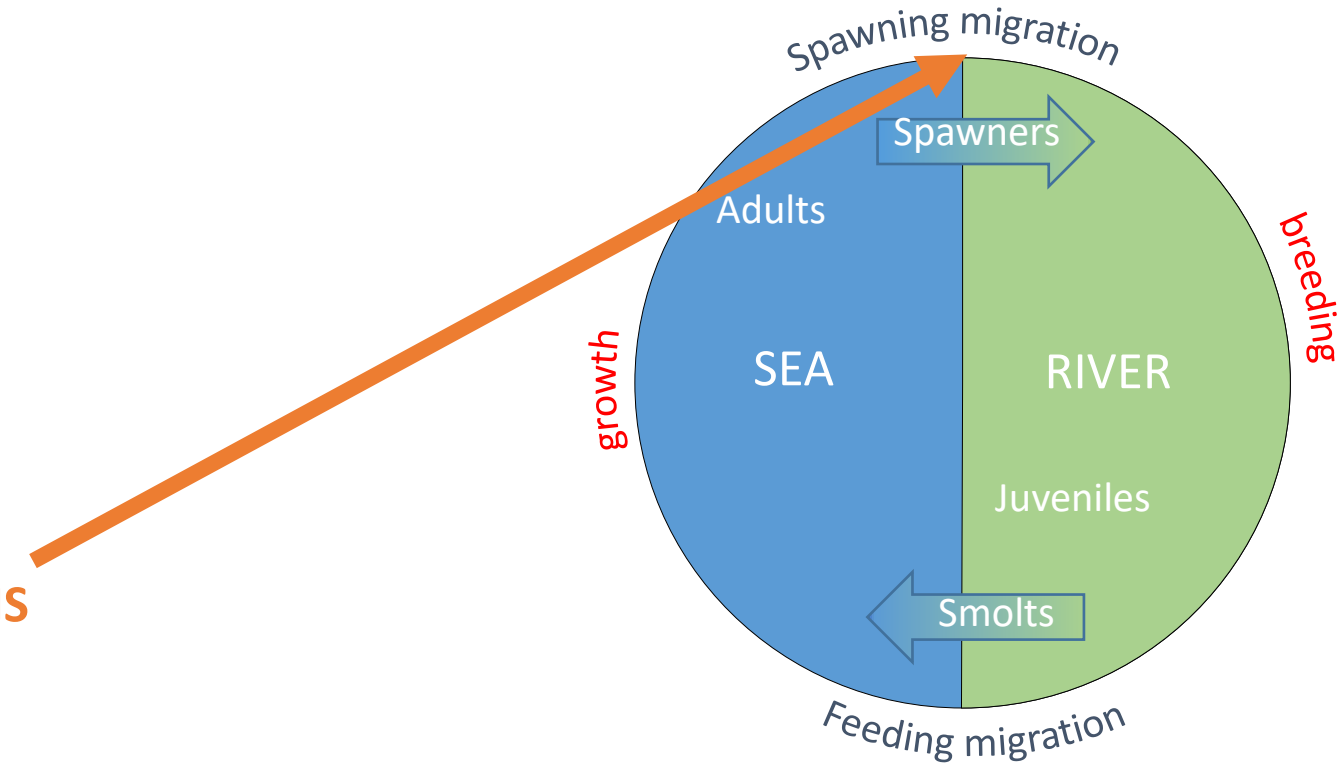
- Difficult to observe
- Fragmentary knowledge about the physiological and ecological mecanisms occurring at sea

Atlantic salmon:

↘ Abundance

Changes in **life history traits**

- Age at maturity
- Size at maturity



Chaput *et* al, 2012
Olmos *et* al, 2018
Bal *et* al, 2017
Jonsson *et* al, 2016
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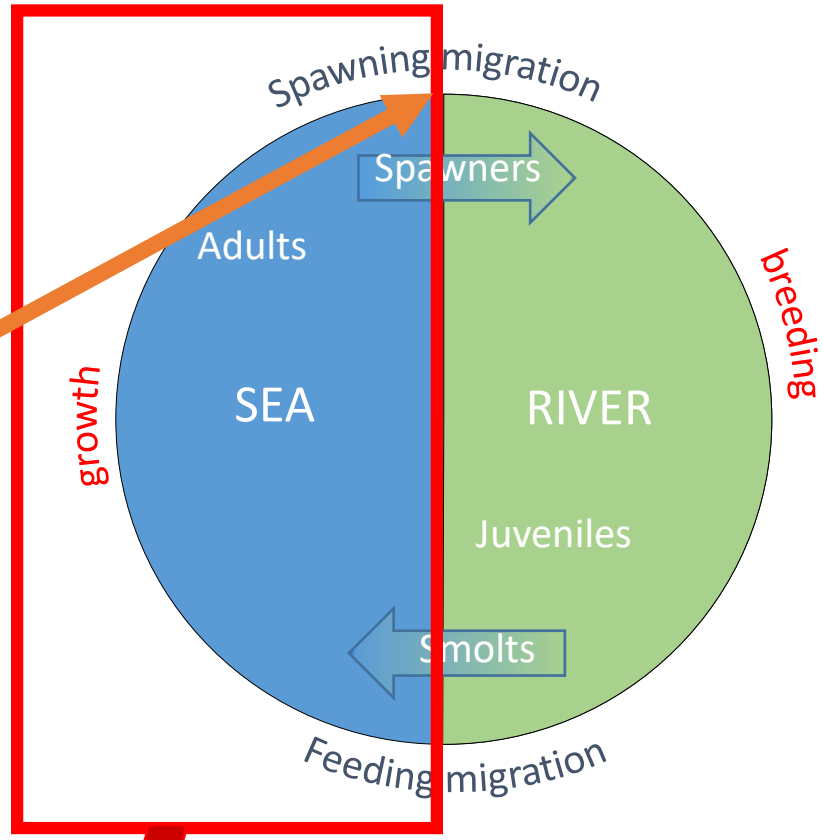
RETURNS



MECANISMES ?

➔ Need to develop a better understanding of the drivers and the mecanisms responsible for the changes in salmon life history traits in order to better understand the population dynamics and to produce management recommendations.

Introduction: Recommendations for salmonids management

SAMARCH: SALmonid MAnagement Round the CHannel

Objective : improve the scientific expertise and the effectiveness of management of migratory salmonid populations in the Channel area.

10 partners from France and England (2017-2022)

4 Work Packages:

WP1	Fish Tracking
WP2	Genetic Tool Development
WP3	Toward Salmonid Stock Assessment Models
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European Regional Development Fund

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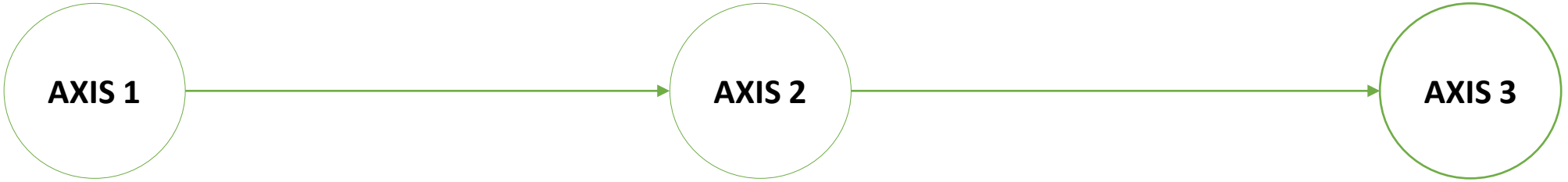
→ 2 PhD projects started in 2018

Olivia Simmons
Bournemouth University

Cécile Tréhin
INRA

PhD project SAMARCH: 2018-2021

Response of migratory salmonid populations to global changes



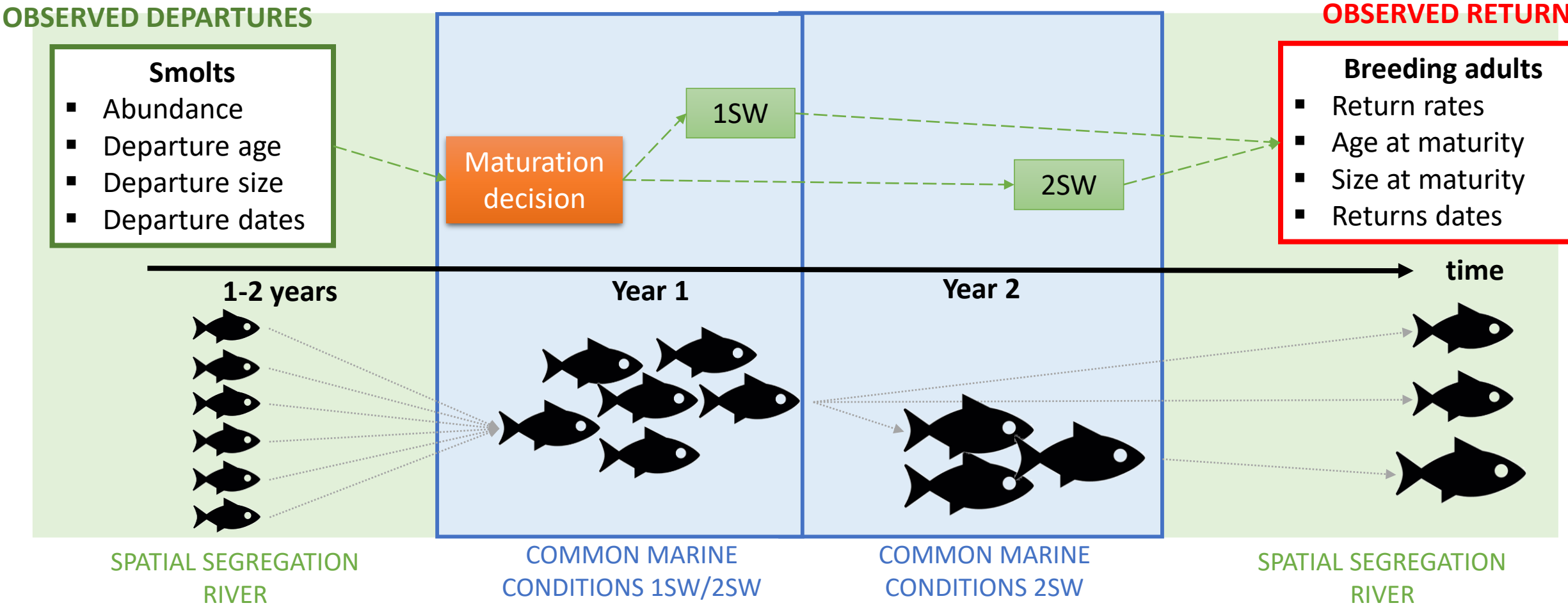
WHAT ARE THE MECANISMS RESPONSIBLE FOR THE OBSERVED LONG-TERM PHENOTYPIC CHANGES ?

- SIZE AT MATURITY
- AGE AT MATURITY
- RETURN RATE

Assumptions : A conditionnal life cycle

SMOLTS
1FW : one-freshwater-winter
2FW: two-freshwater-winter

BREEDING ADULTS
1SW : one-sea-winter
2SW: two-sea-winter



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- **Genetic :** Vgll3 (Barson et al. 2015)
- **Flexibility :**
  Physiological tresholds ~ growth
  (Hutching and Jones, 1998;
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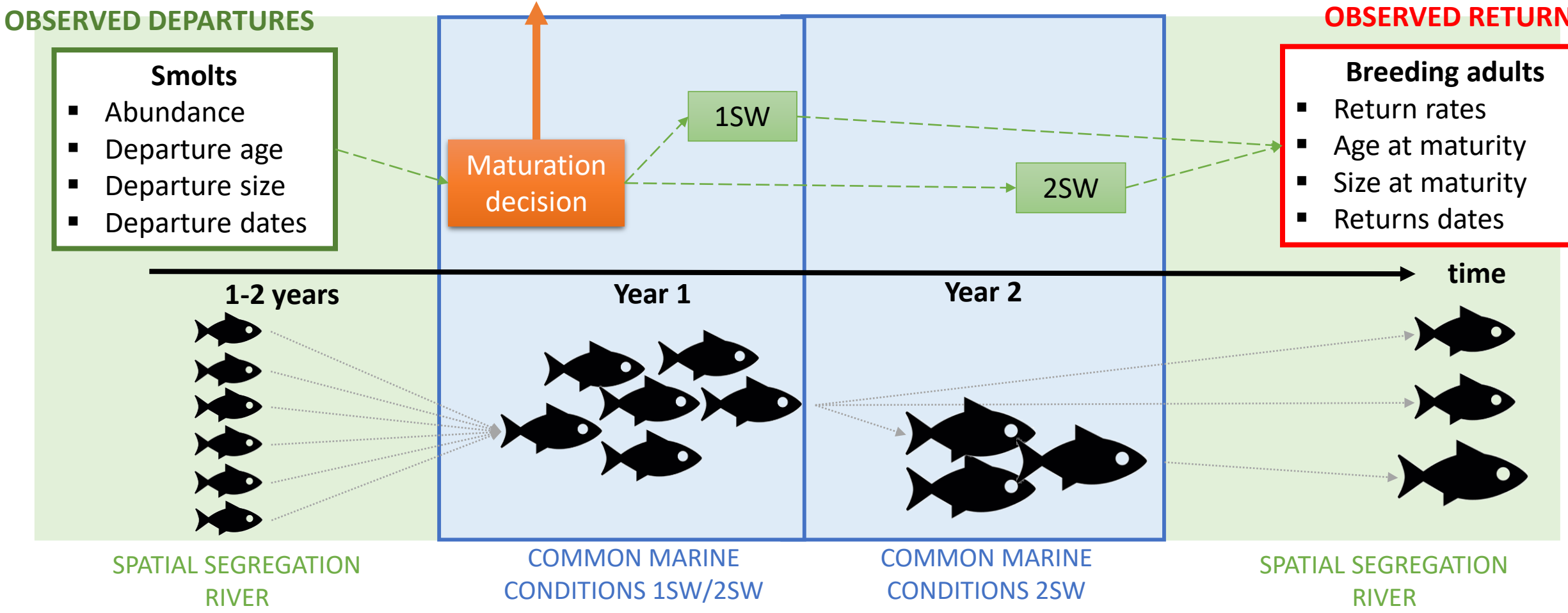

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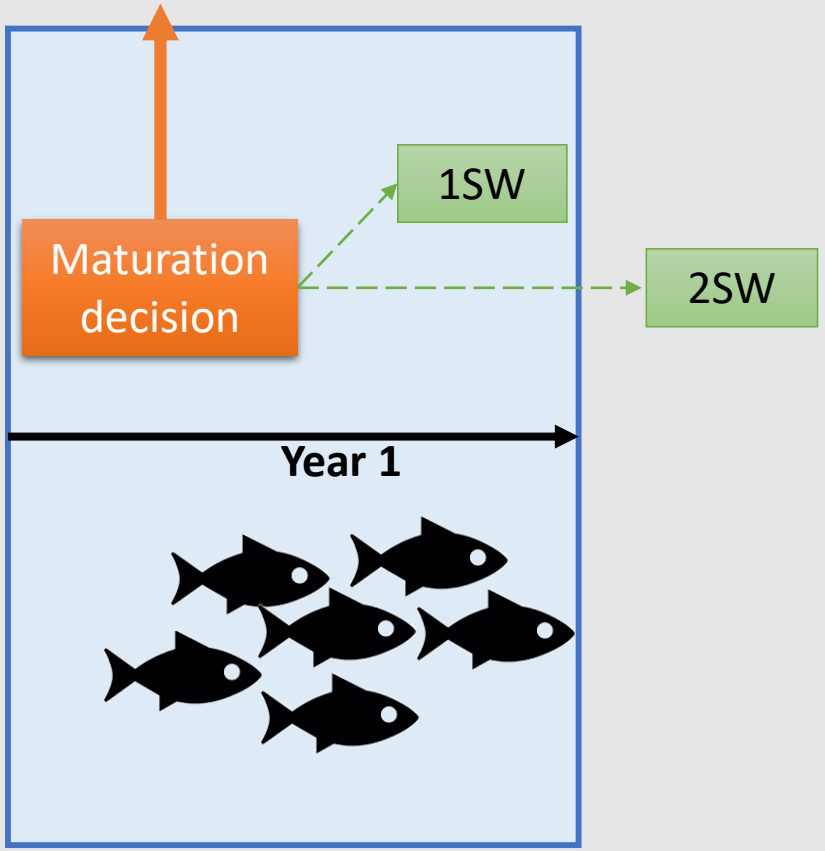
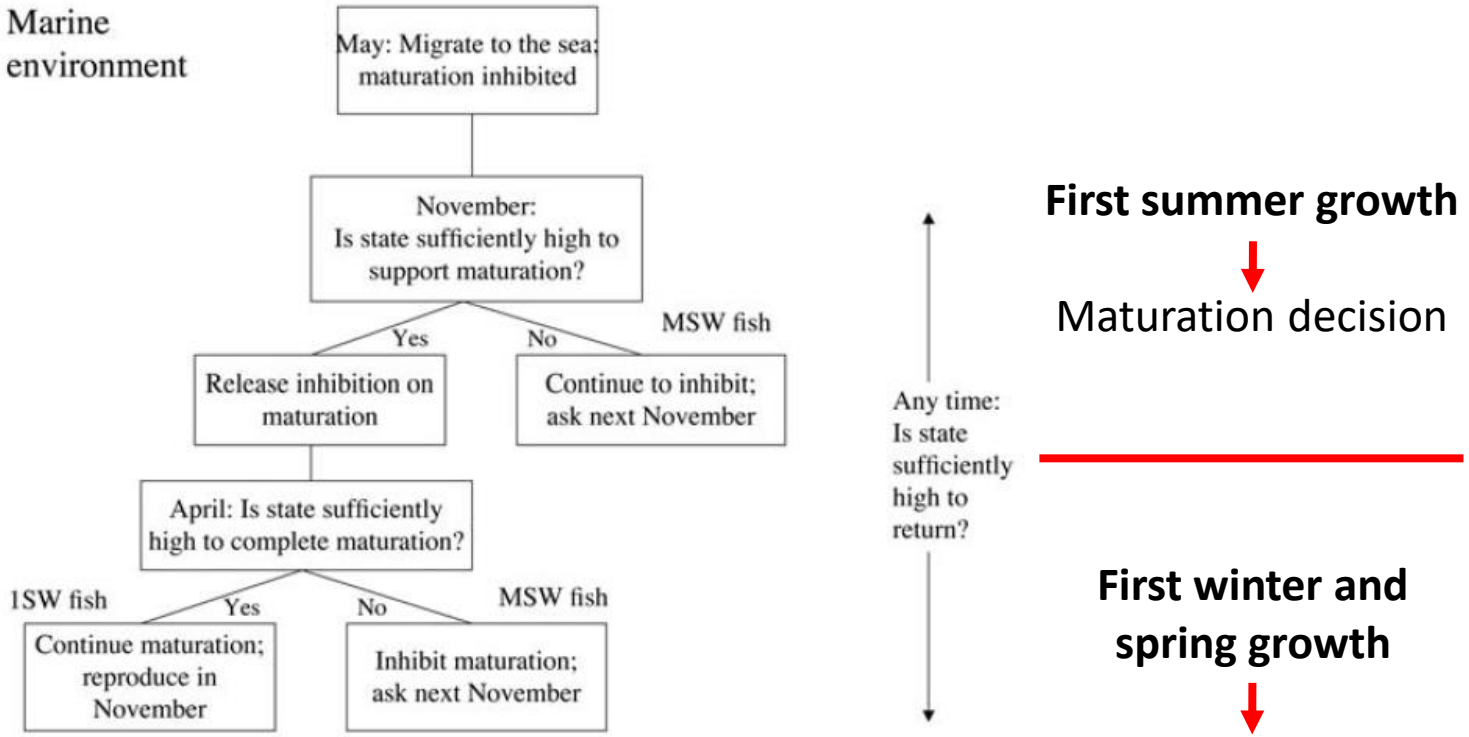


COMMON MARINE CONDITIONS 1SW/2SW

Hyp. 1 : Maturation threshold ~ 1st summer growth at sea



Mangel and Satterthwaite, 2018

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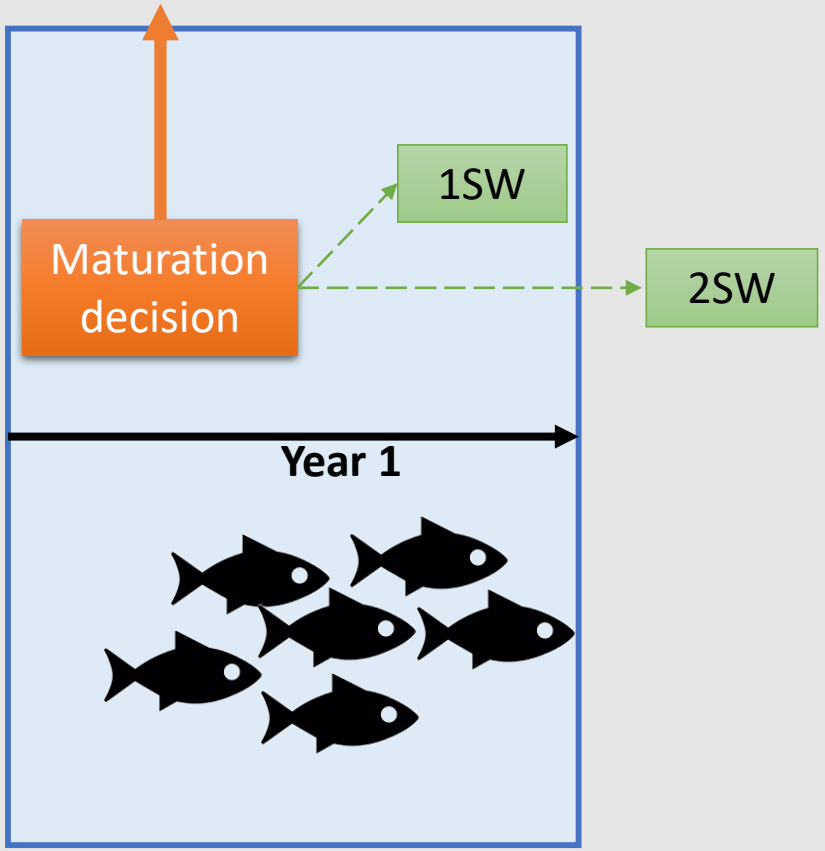


COMMON MARINE CONDITIONS 1SW/2SW

Hyp. 2 : Female maturation threshold > Male maturation threshold

♂ ≠ ♀

Sex-dependent strategies

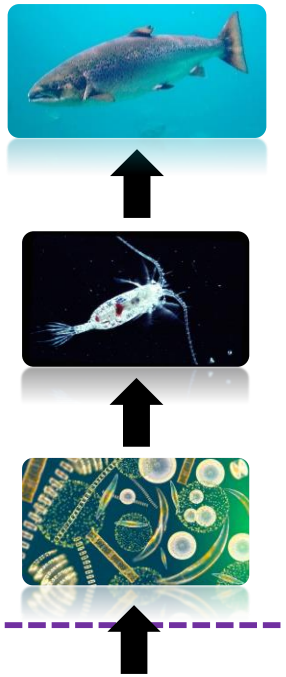
- Sex-specific dominance on Vgll3 gene (Barson et al. 2015)
- Stronger correlation between fecondity and body condition for females (Fleming et al. 1998)
- **Different growth maturation thresholds ?**

Assumptions : Consequences of long term environmental changes

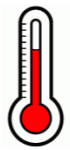
Hyp. 3 : Changes in marine conditions → decreasing growth

Indirect effects through the pelagic food web

EFFETS BOTTOM-UP



Direct effects of climate change



PROCESSES

Growth
Key events timing
Survival

LIFE HISTORY TRAITS

Size at maturity

Age at maturity

DEMOGRAPHY

Reproductive success

↓

Rate of population increase

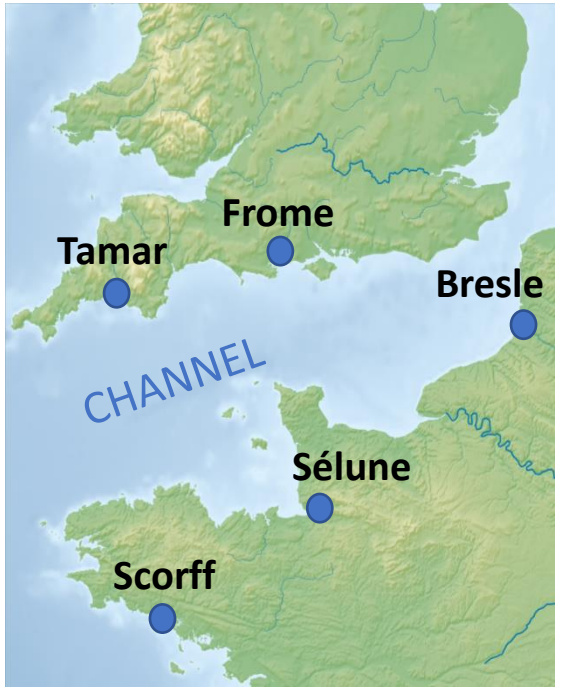
♂ ≠ ♀

Building a unique dataset

Historical scales collections (10 - 30 years) + ongoing sampling

~ 9600 scales : 1 scale /individual
Smolts (1FW + 2FW) and adults (1SW + 2SW)
Atlantic salmon

5 index rivers in the Channel zone



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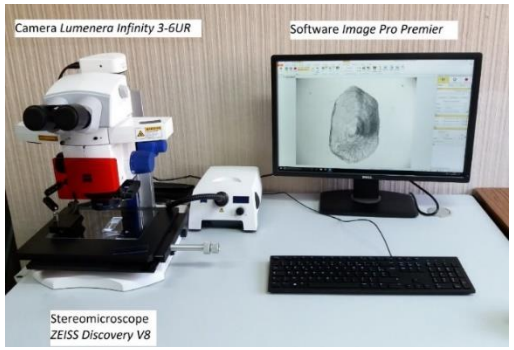
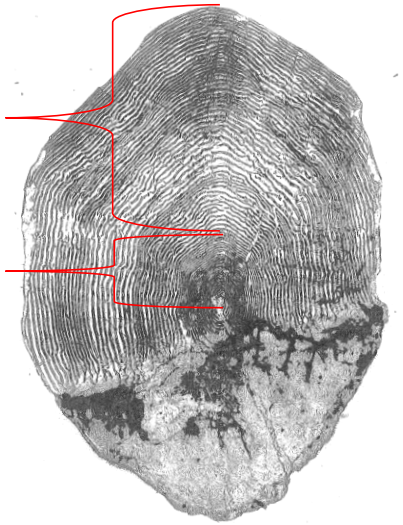


Marine growth

River growth




Ludivine Lamireau


Frédéric Marchand

Stephen Gregory

Bill Beaumont

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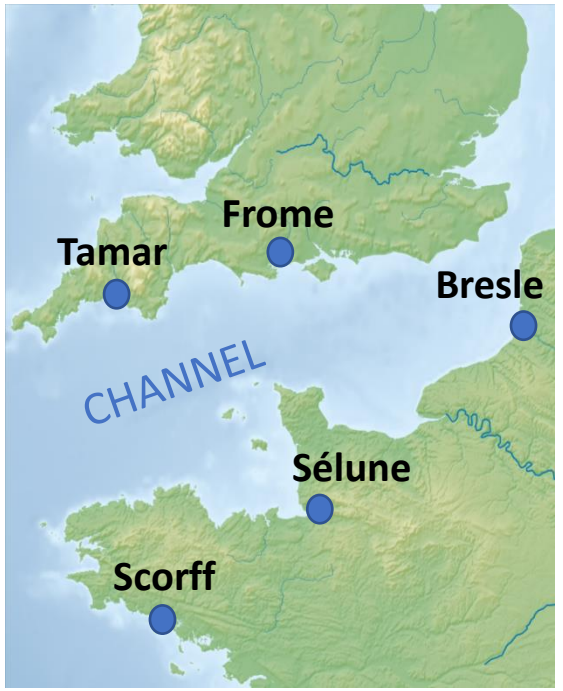

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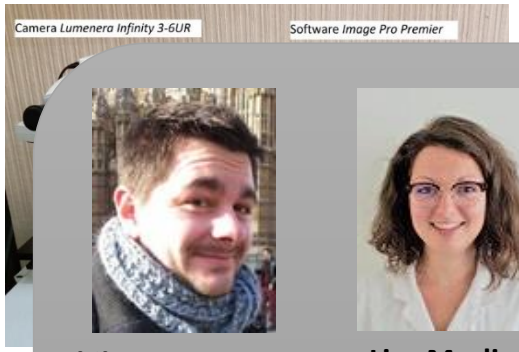
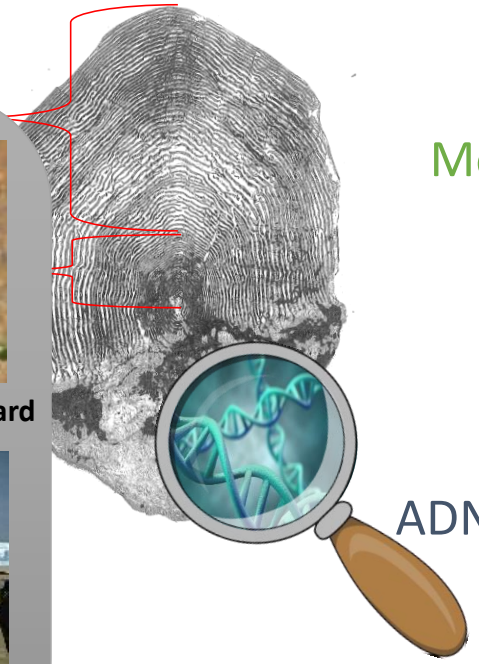


Thibaut Jousseaume — Lisa Meslier — Anne-Laure Besnard

Sophie Launey — Jamie Stevens — Andrew King



Molecular sexing

ADN

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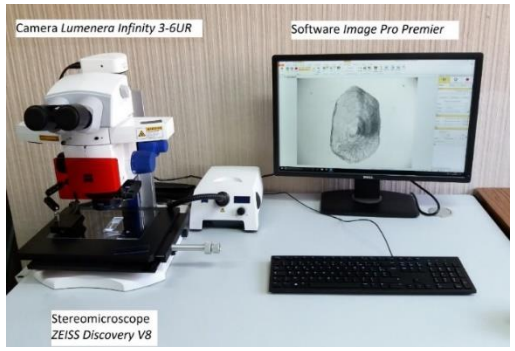

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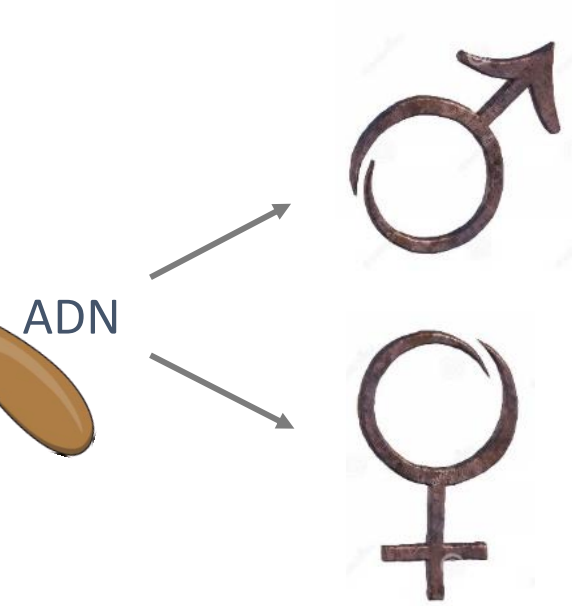

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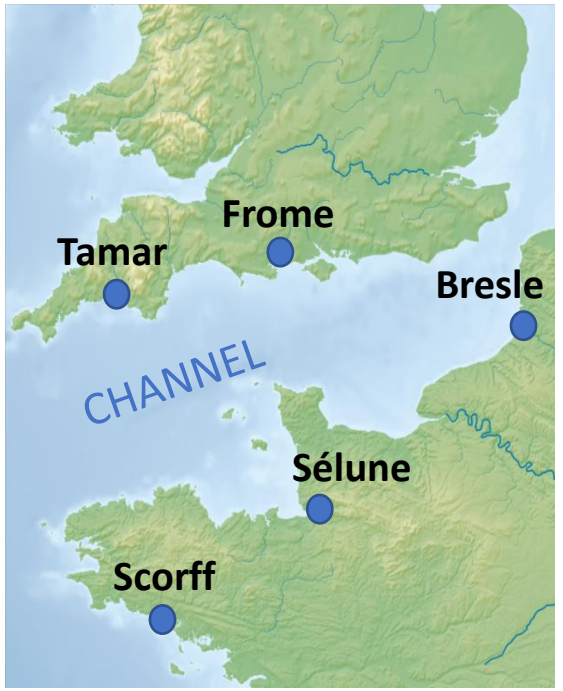

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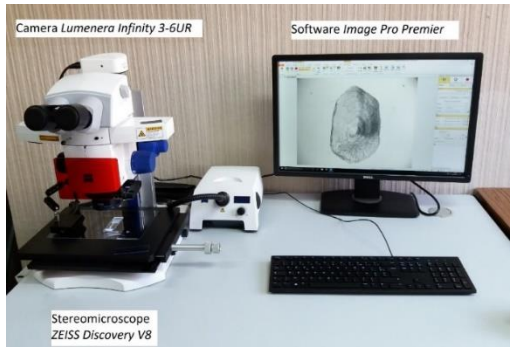

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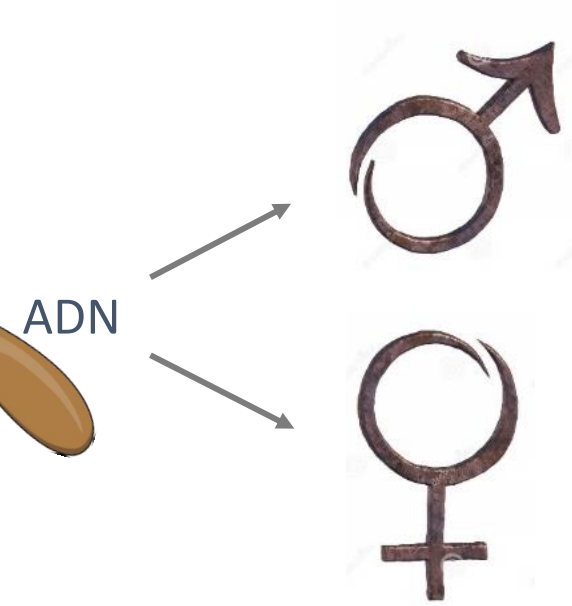


5 index rivers in the Channel zone

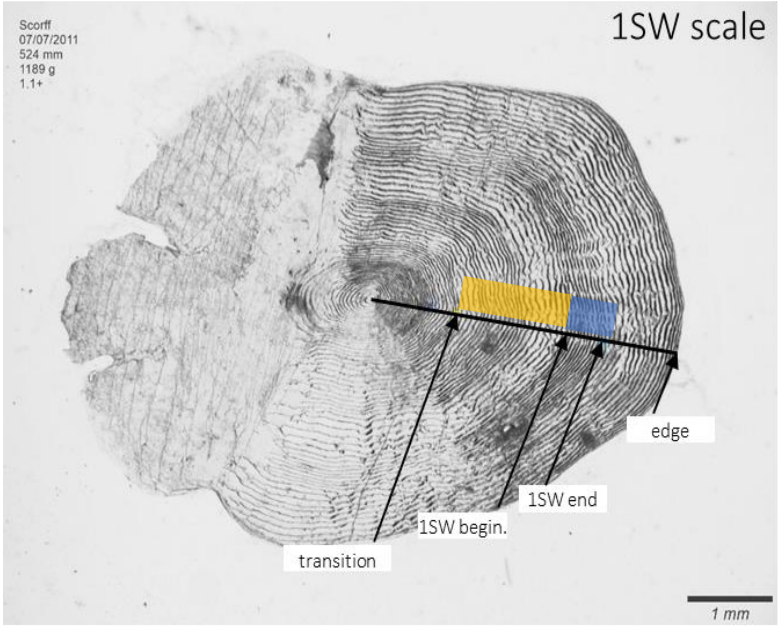
Focus on Selune dataset

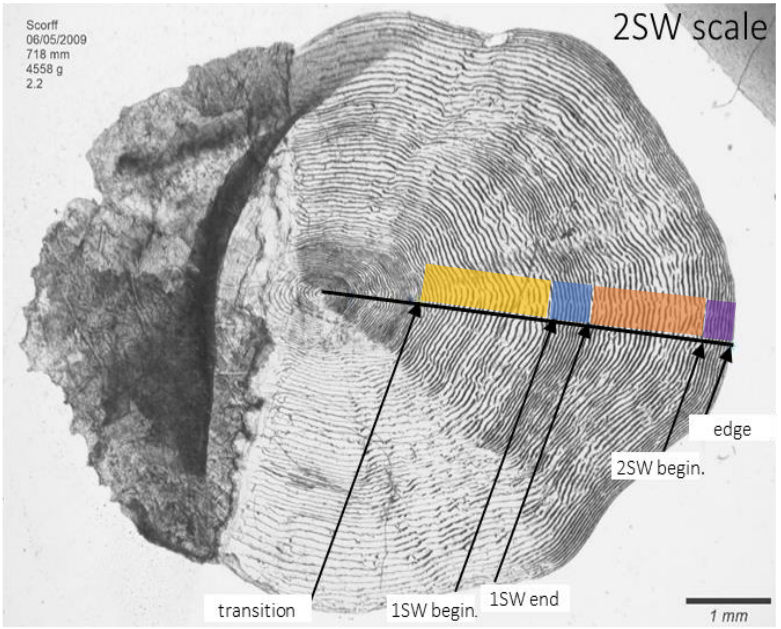
- 30 years: 1987 → 2017
- Sample of 1848 adults, 958 smolts
- Capture site (ORE DiaPFC) + recreational angling (CNICS)

Focus on Selune dataset

Determination of growth variables on adult scales

- First summer growth
- First winter growth
- Second summer growth
- Second winter growth





Material and methods

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Individual phenotypic information

- River and sea age
- Sex
- Total length (Lt), weight (M), Fulton condition factor ($K = M \times Lt^{-3}$)
- Return dates

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Estimations at the population scale from capture site data

- Annual return rate
- Annual proportions of 1SW and 2SW

Results: Long term trends in first year growth

- How did growth vary among sea-age class and sex during the first year at sea ?

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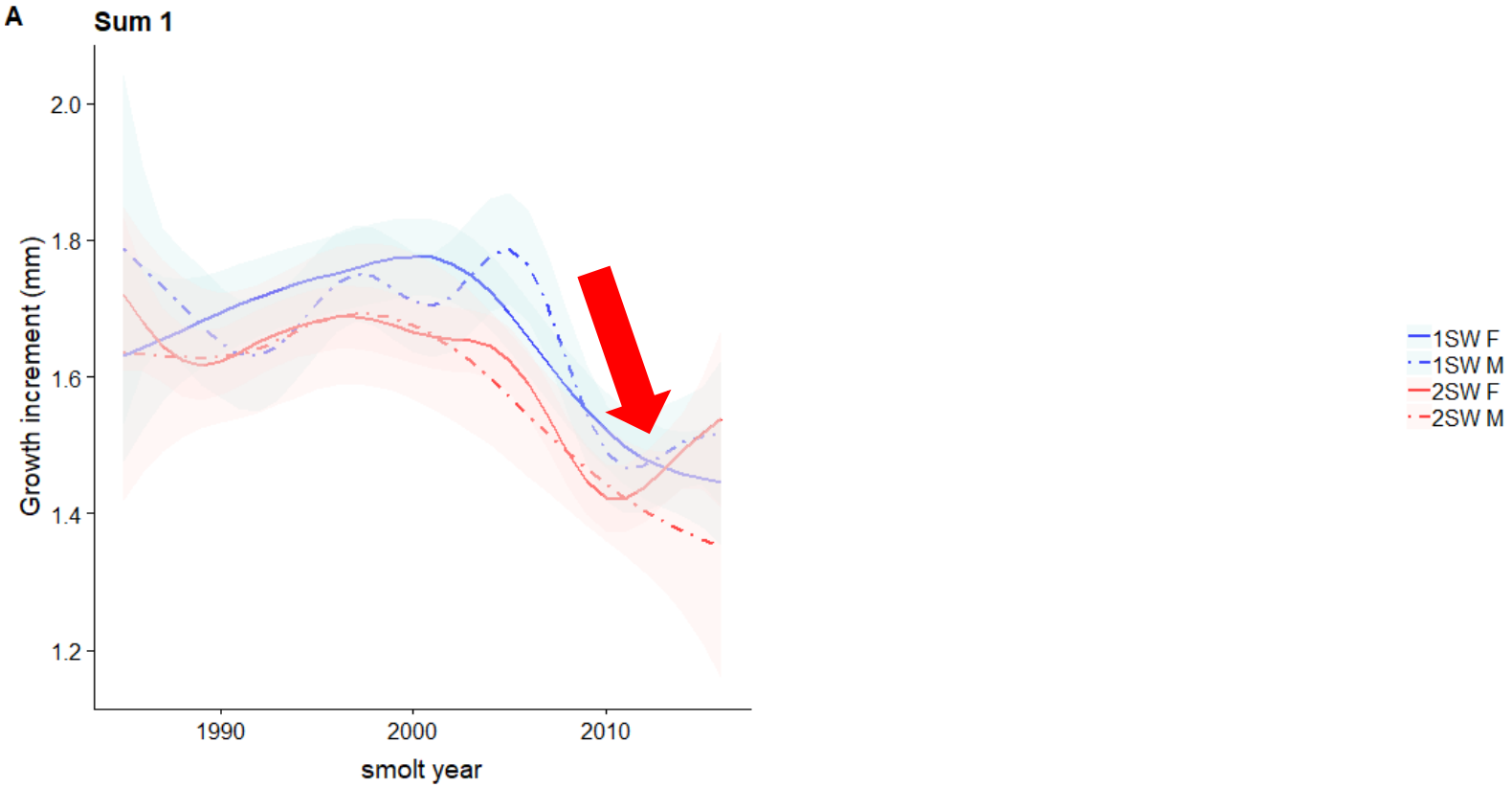
GAMs models : sum 1 / win 1 ~ Age * Sex + s(smolt.year, by = Age * Sex)



Best models on AIC

Synchronous (sea-age /sex) trends

Age + Sex + s(smolt.year)

→ Common conditions ?

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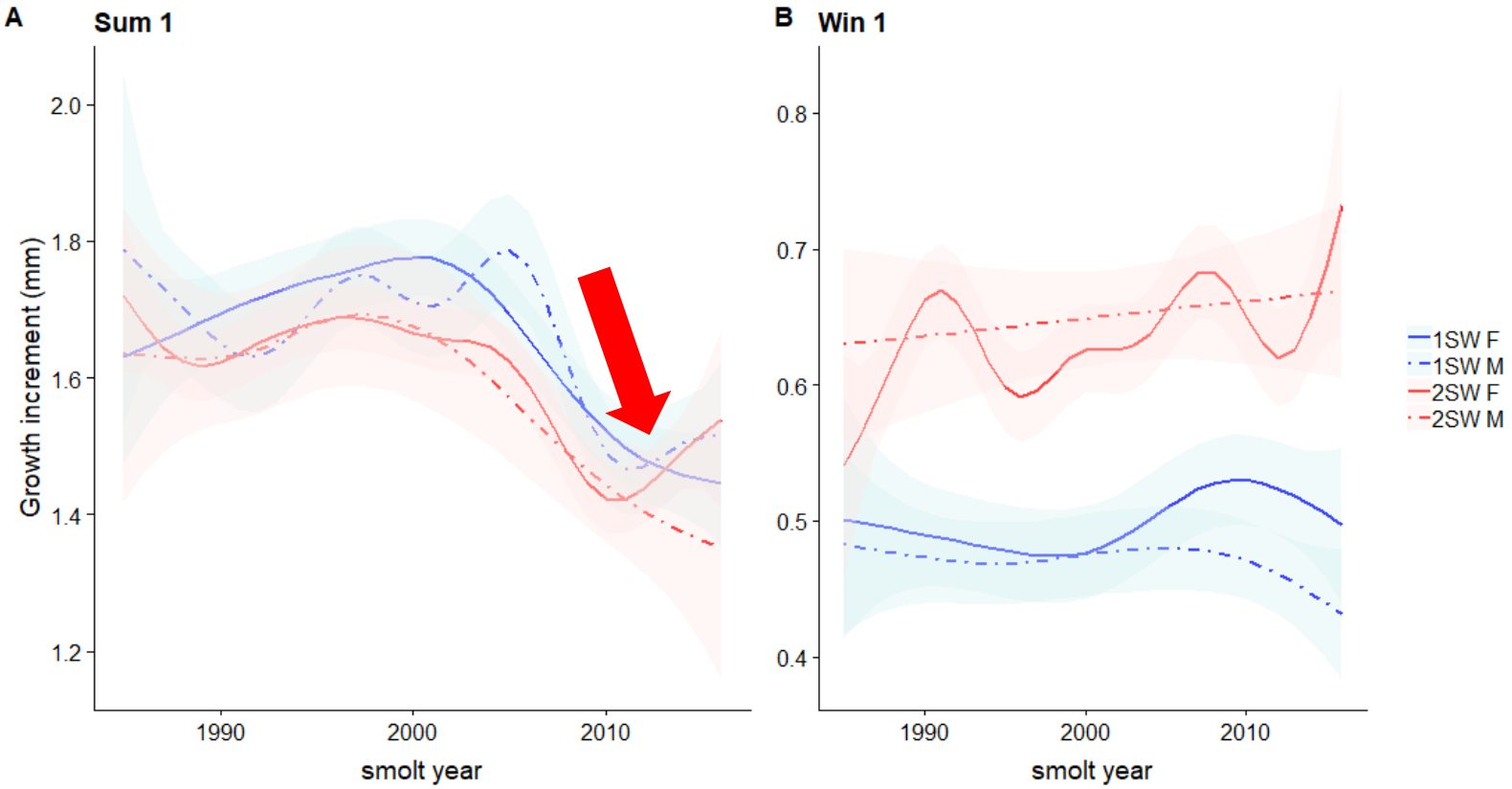

Best models on AIC

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Age + Sex + s(smolt.year)

→ Common conditions ?

Sea-age specific trends

Age + s(smolt.year, by = Age)

→ Different conditions ?

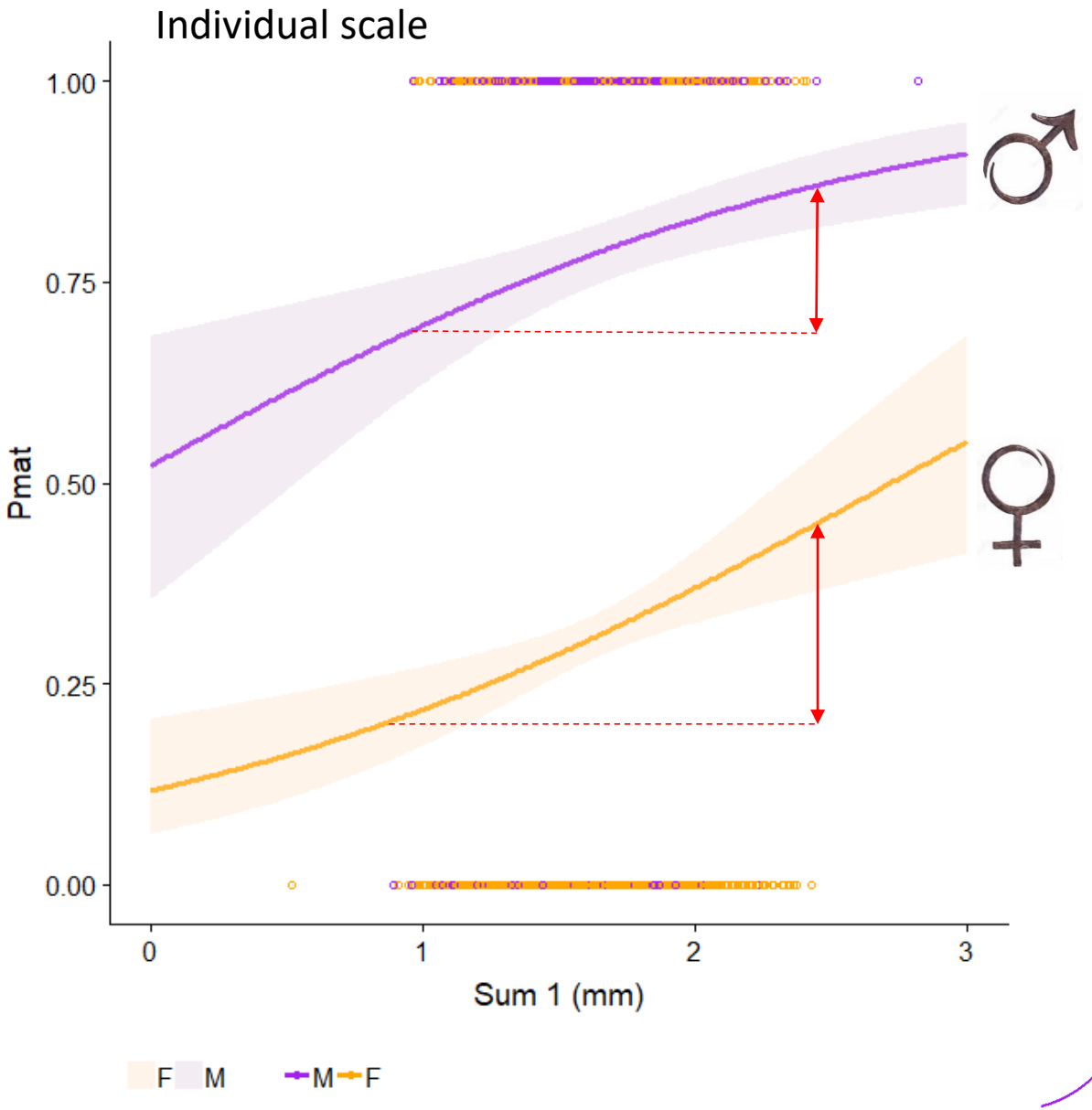
Results: Sex-specific maturation mechanisms

Individual scale

- Individual probability to mature after only one year at sea (Pmat) ~ sex specific growth thresholds during first summer at sea ?

$$Logit(Pmat_i) \sim Sum1_i * sex_i$$

Results: Sex-specific maturation mechanisms



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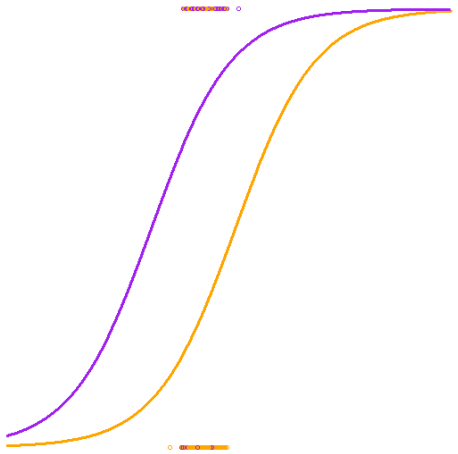


Sex-specific maturation thresholds ~ growth

Results: Sex-specific maturation mechanisms

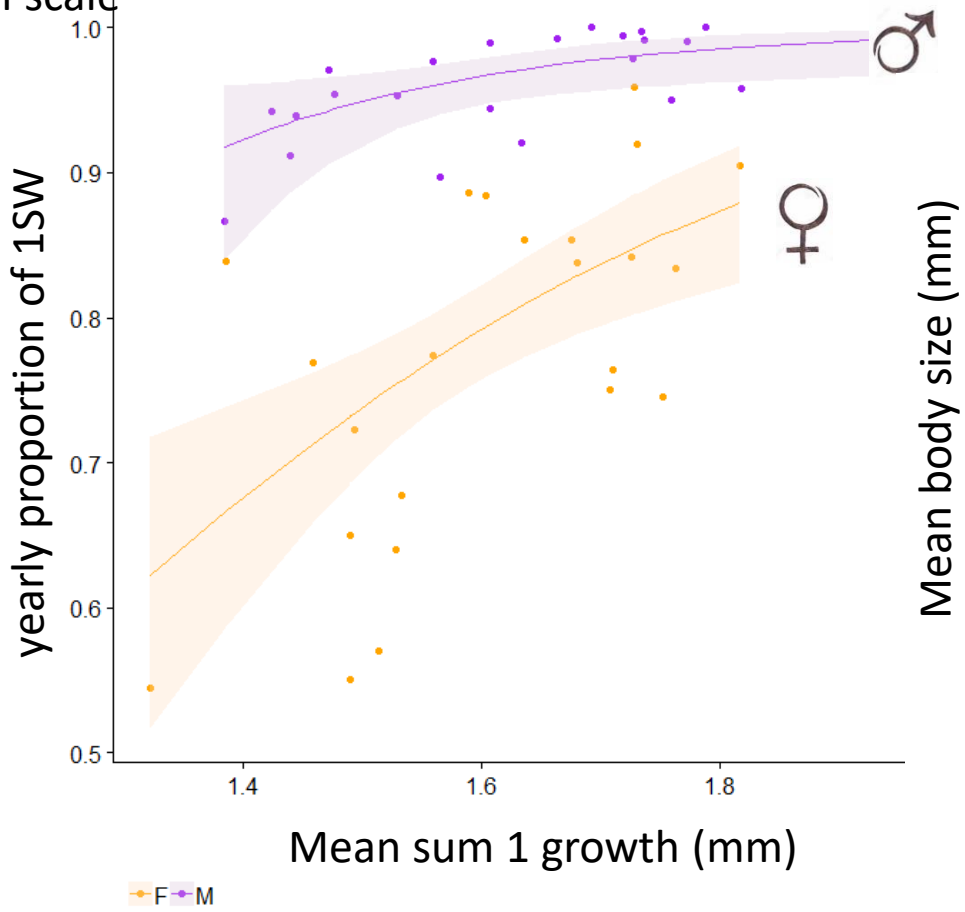
- Are inter-annual variations in mean summer growth related to fluctuations in the annual proportion of 1SW and mean body length ?

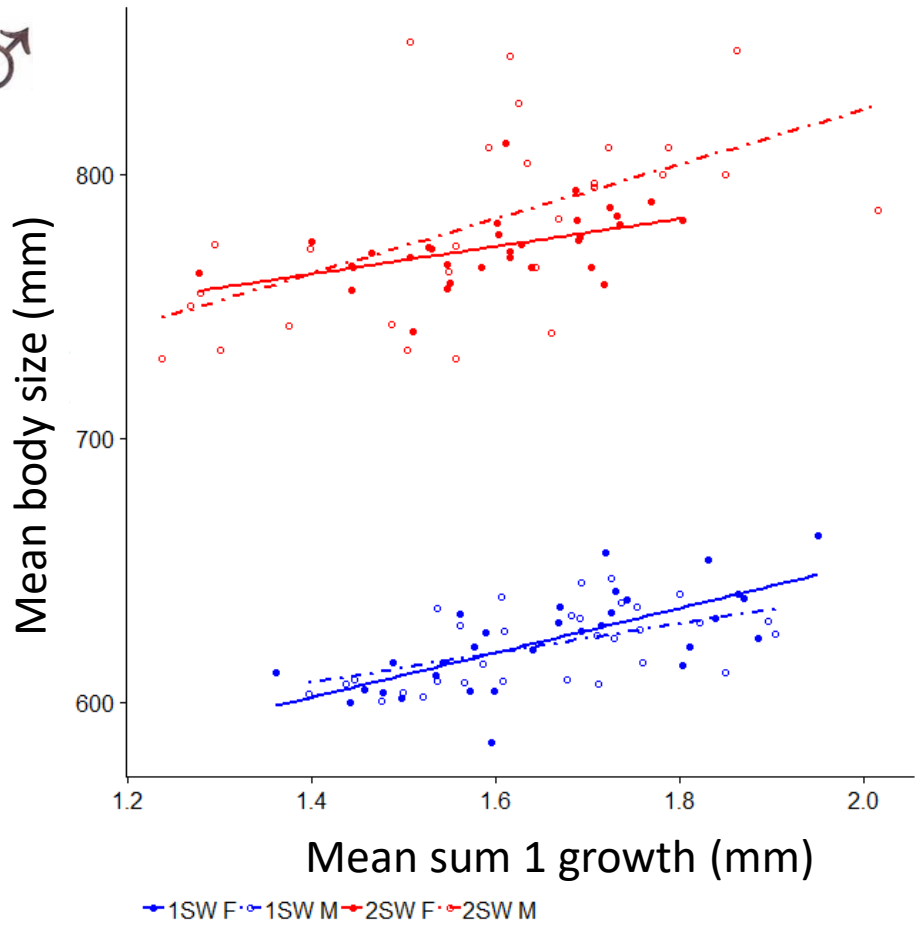
Population scale

Results: Sex-specific maturation mechanisms

- Are inter-annual variations in mean summer growth related to fluctuations in the annual proportion of 1SW and mean body length ?

Population scale





Prop (1SW) ± **Sum 1**

Sex-specific response

Size at maturity ± **Sum 1**

Results: Consequences on long term trends in life history traits

- What are the consequences on long-term changes in size at maturity in returns and sex-specific maturation strategies ?

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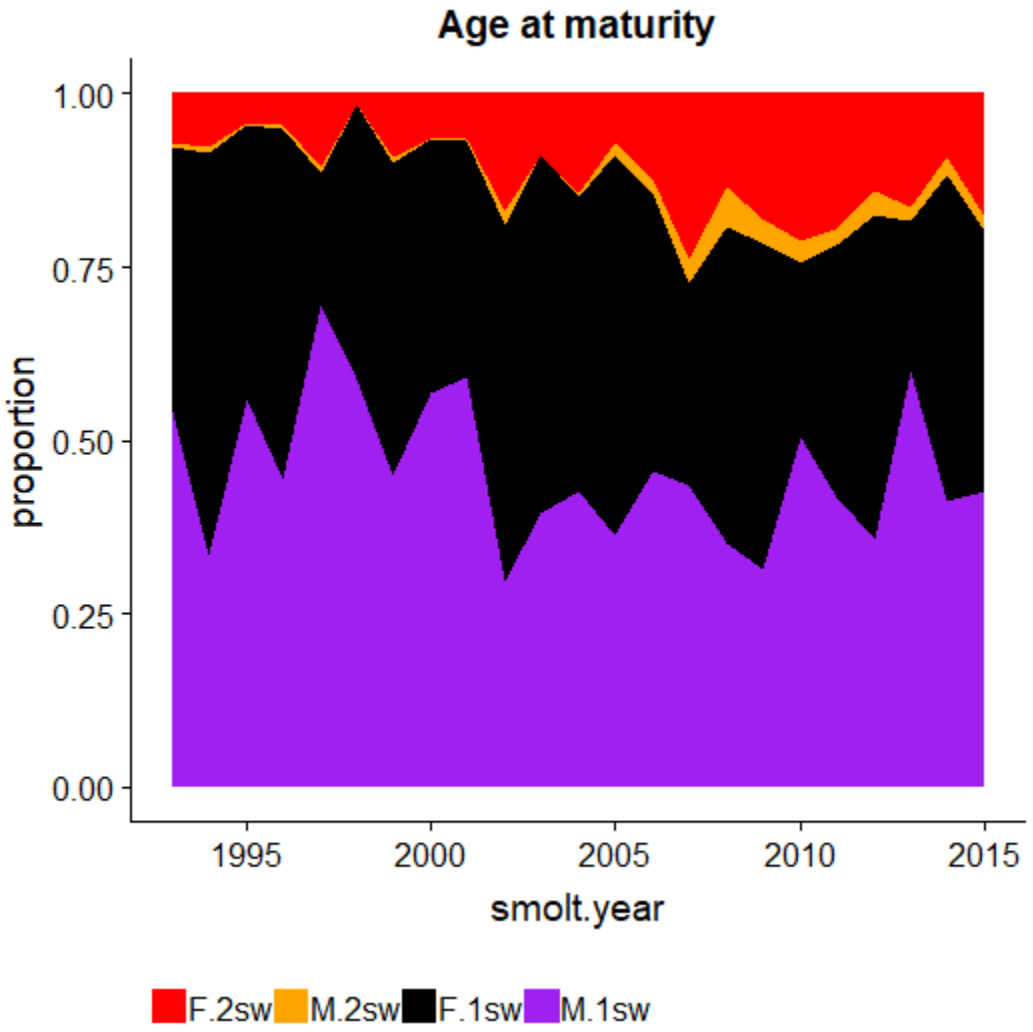

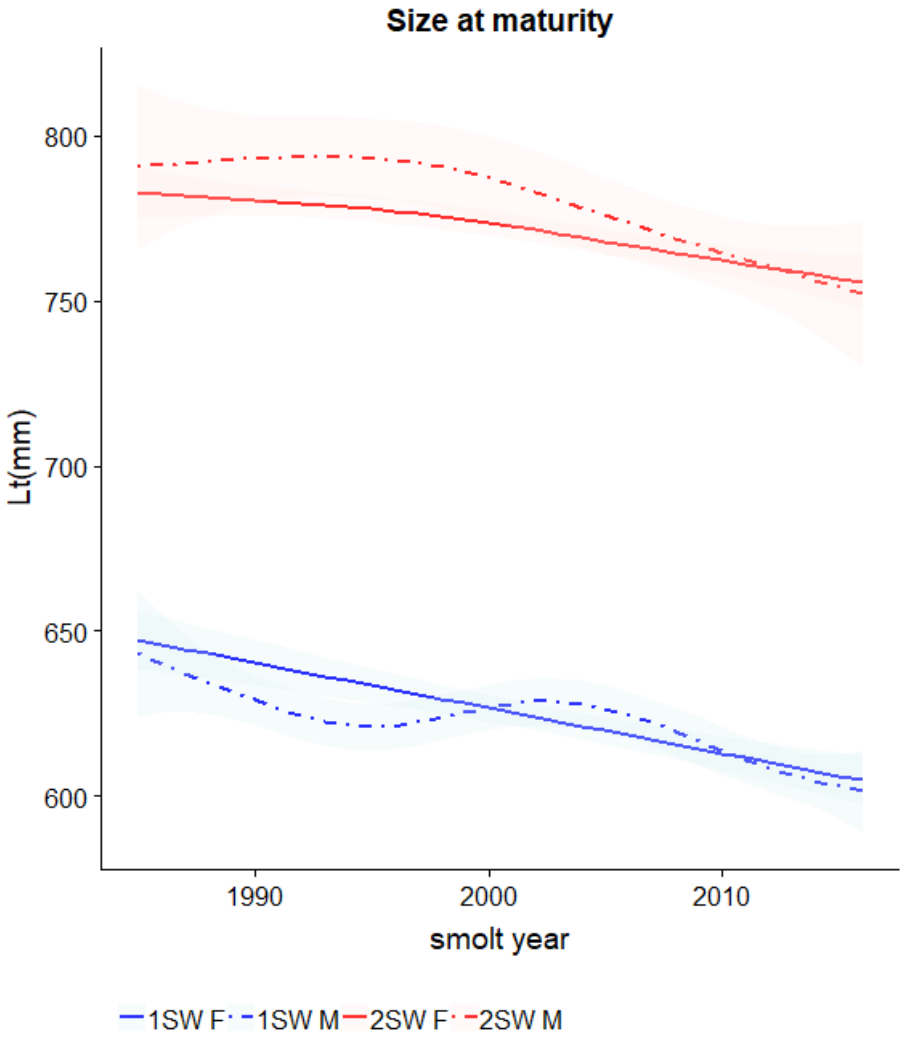

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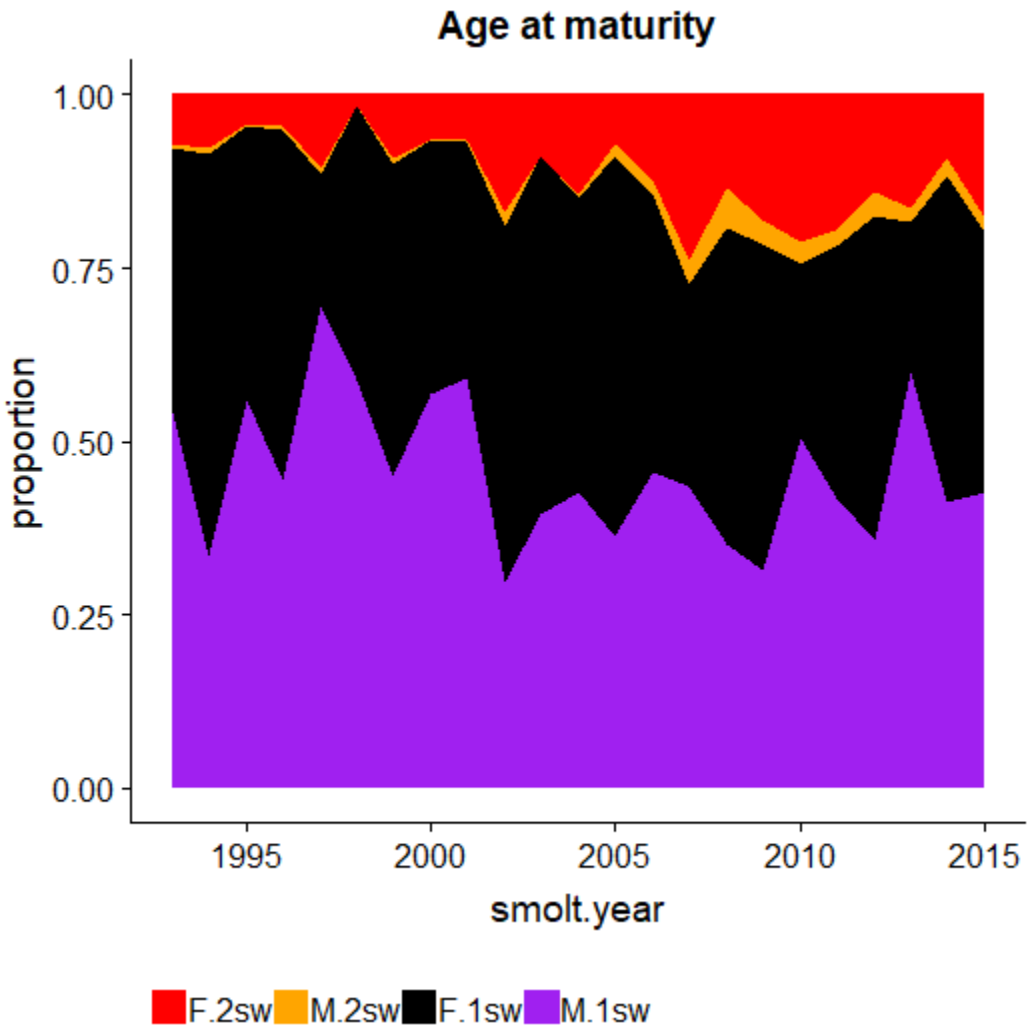
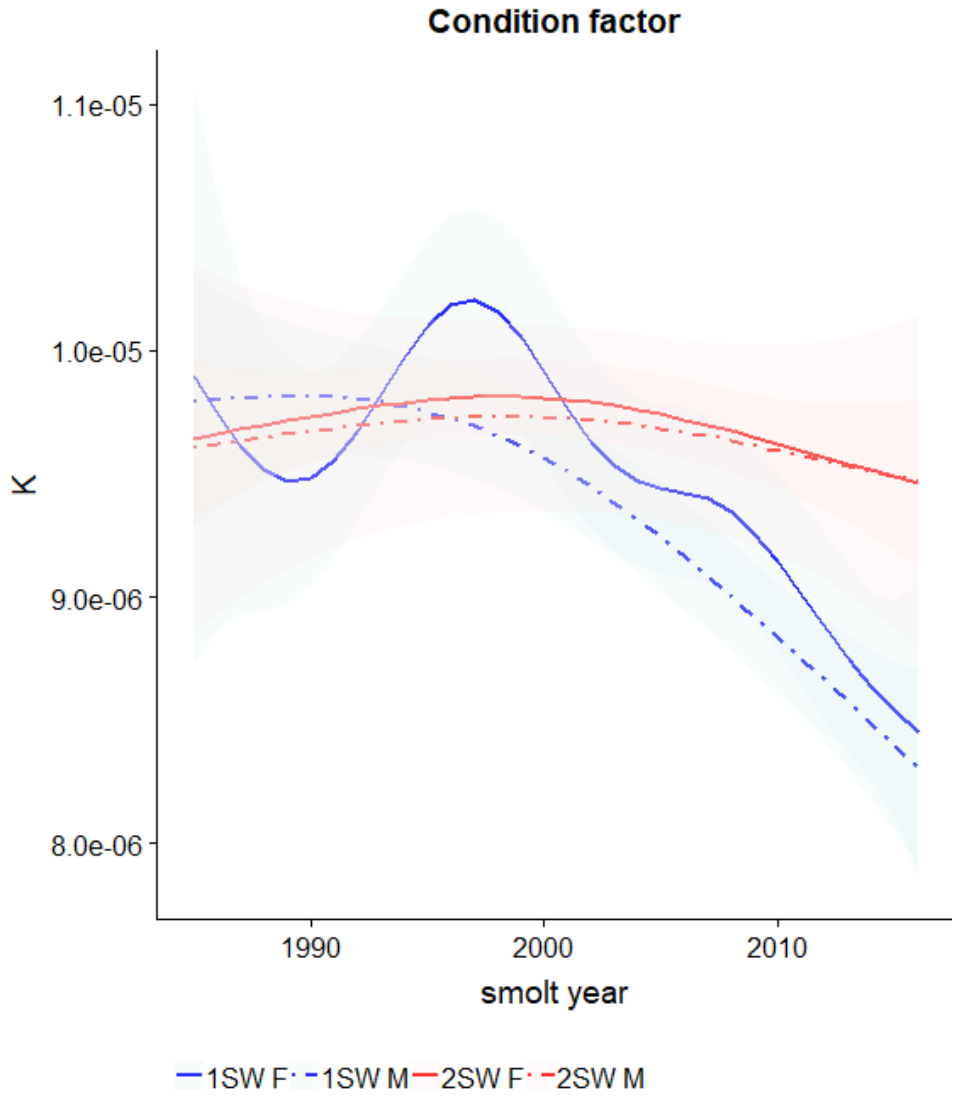




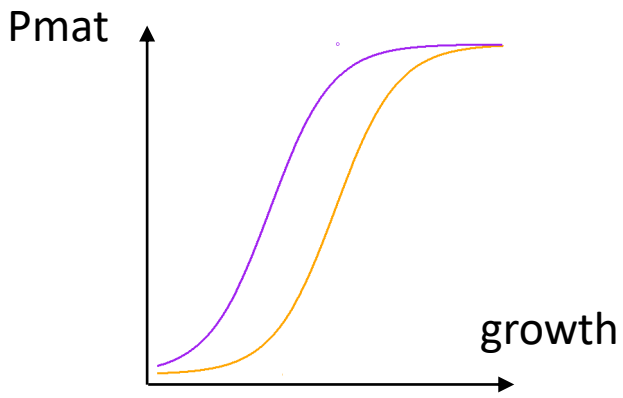
Discussion

MATURATION MECANISMS AT THE INDIVIDUAL SCALE

1st summer growth

Maturation treshold

♀ > ♂



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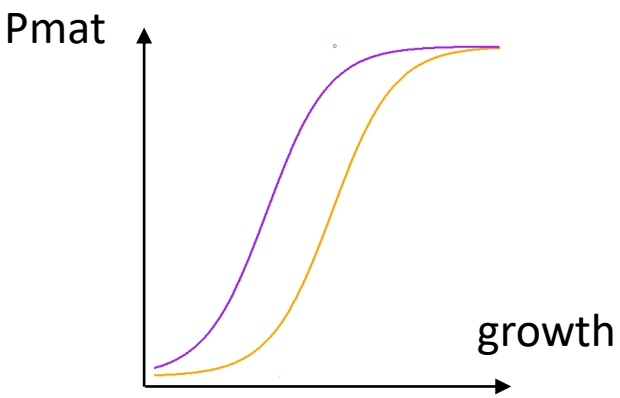

RESPONSE TO GROWTH FLUCTUATIONS AT THE POPULATION SCALE

Inter-annual variation in mean summer growth

↓ +

- Proportion of 1SW

Sex-specific relationship

♀ > ♂

- Mean size at maturity

Discussion

MATURATION MECANISMS AT THE INDIVIDUAL SCALE

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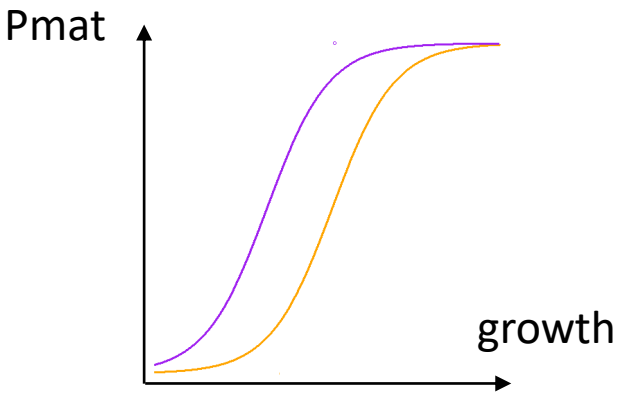

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EXPLANATION FOR LONG-TERM TRENDS IN LIFE HISTORY TRAITS IN RETURNS

↓ First summer growth

After 2000s : +++

↓

↓ Proportion of 1SW / Age at maturity

♀ > ♂

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Discussion

MATURATION MECANISMS AT THE INDIVIDUAL SCALE

1st summer growth

⇩

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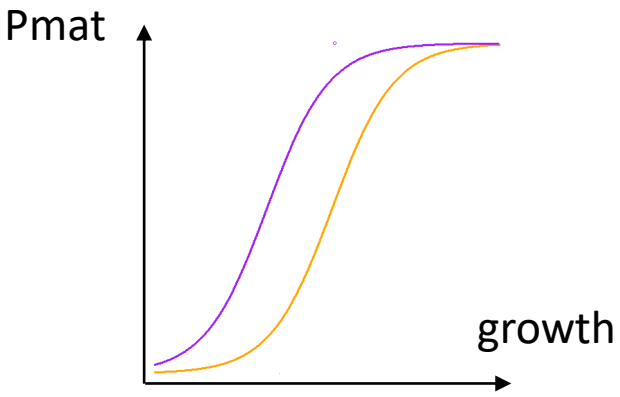

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↘ Mean size at maturity

Proximal mecanisms theory ?

Altered growth conditions ➔ delayed maturation tresholds

PhD project SAMARCH: 2018-2021

Response of migratory salmonid populations to global changes

AXIS 1 → **AXIS 2** → **AXIS 3**

WHAT ARE THE MECANISMS RESPONSIBLE FOR THE OBSERVED LONG-TERM PHENOTYPIC CHANGES ?

- SIZE AT MATURITY
- AGE AT MATURITY
- RETURN RATE

♂ ≠ ♀

Sex-dependent strategies

PhD project SAMARCH: 2018-2021

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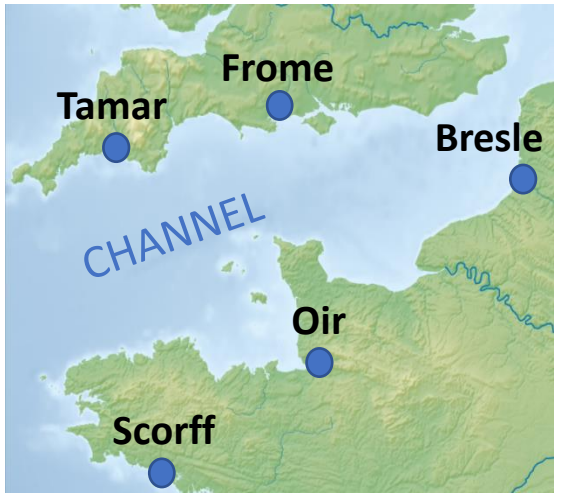
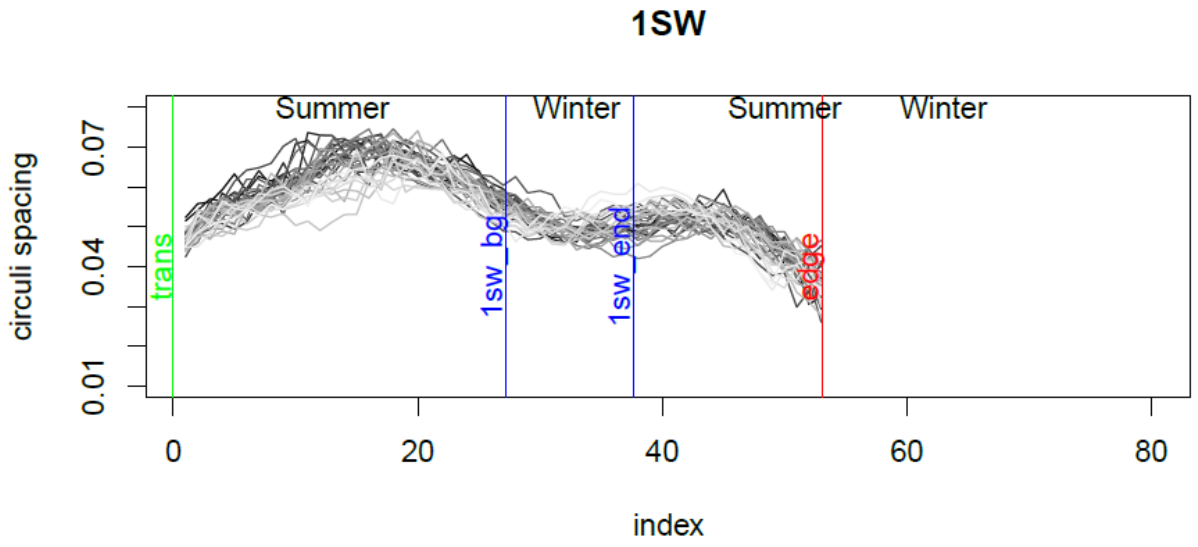
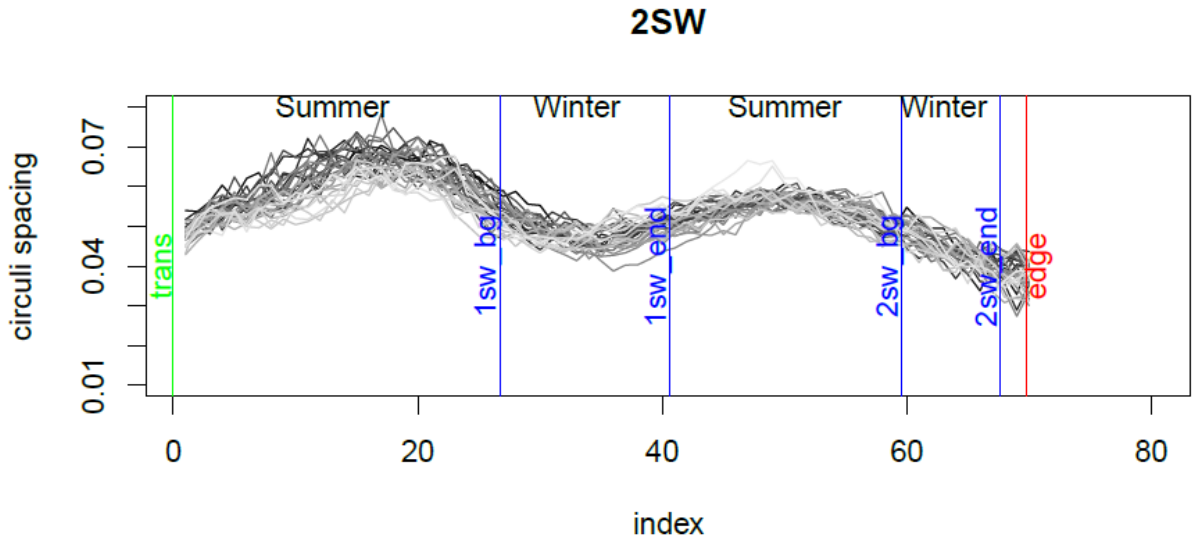
REFINE INDIVIDUAL GROWTH TRAJECTORIES IN CONTINUOUS TIME

INTER-RIVERS COMPARISON



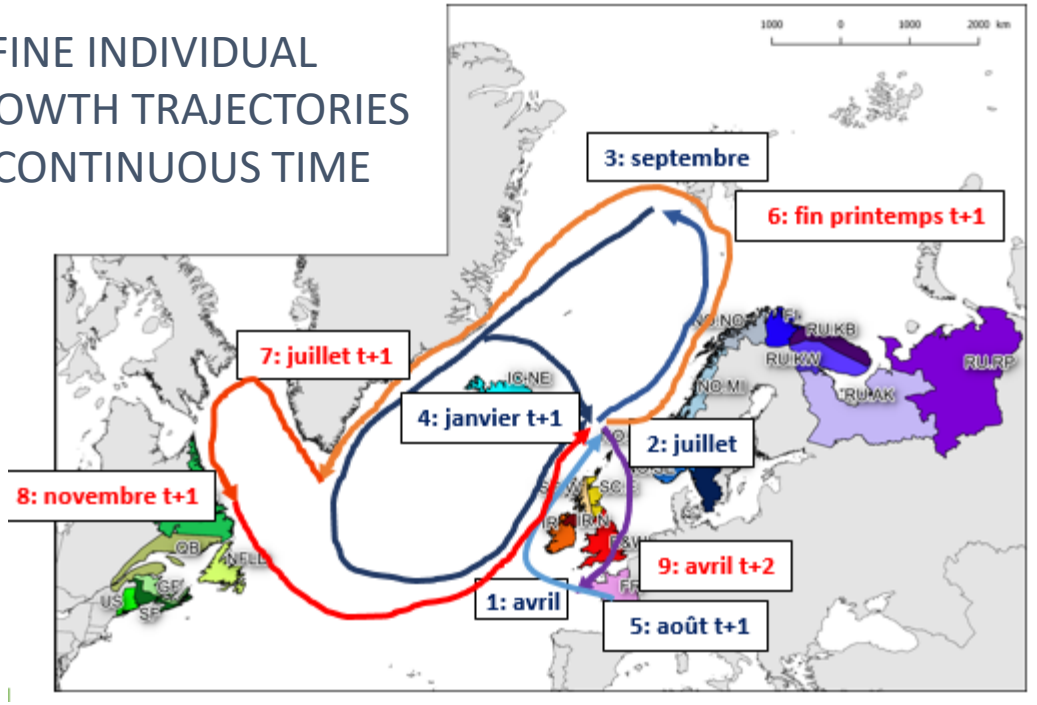
Perspectives





AXIS 2

REFINE INDIVIDUAL GROWTH TRAJECTORIES IN CONTINUOUS TIME



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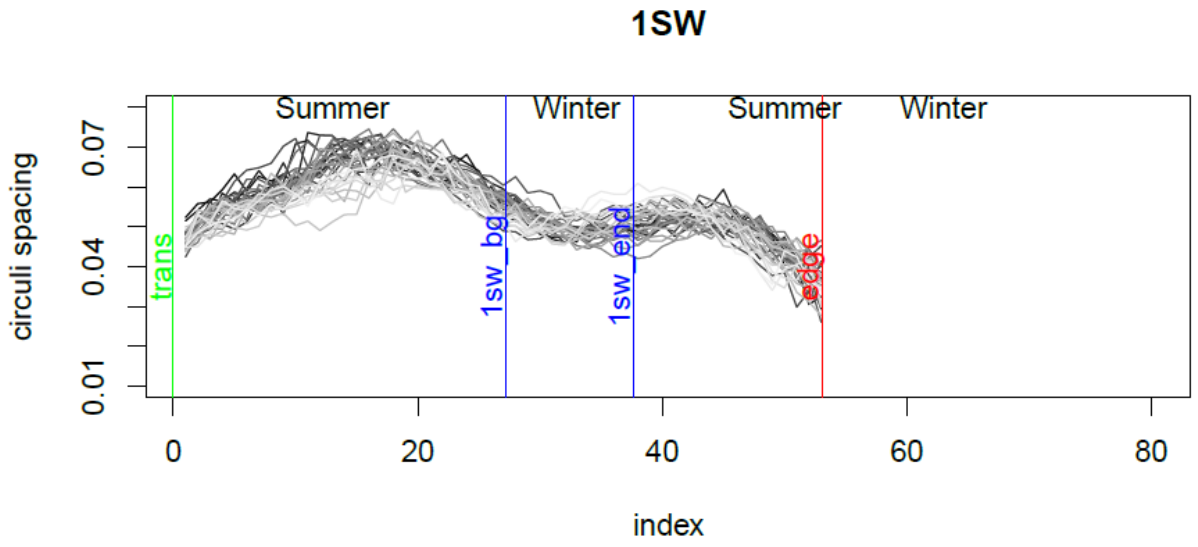
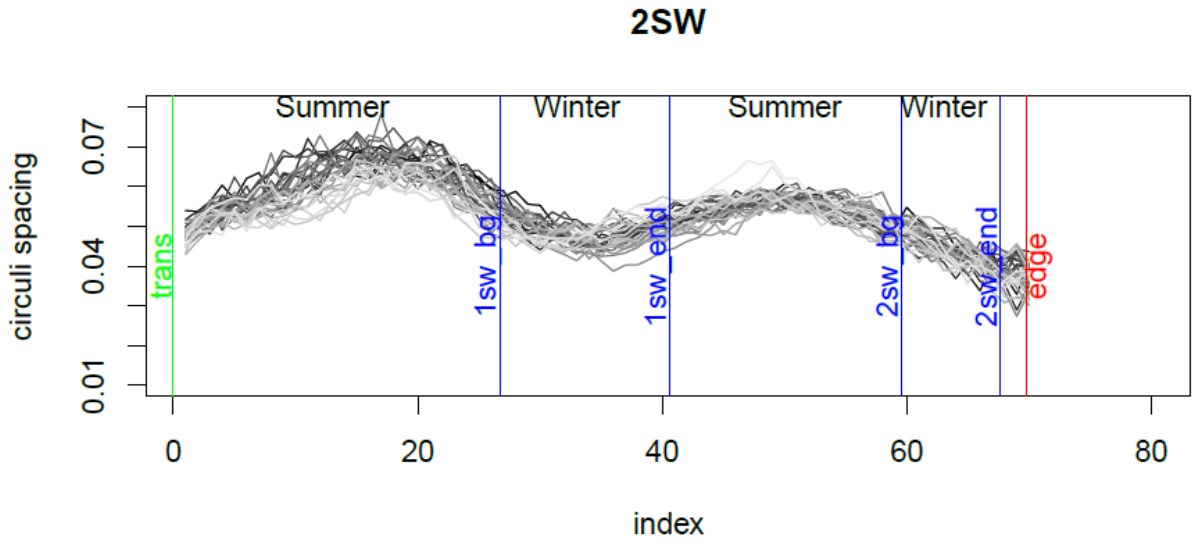




AXIS 2

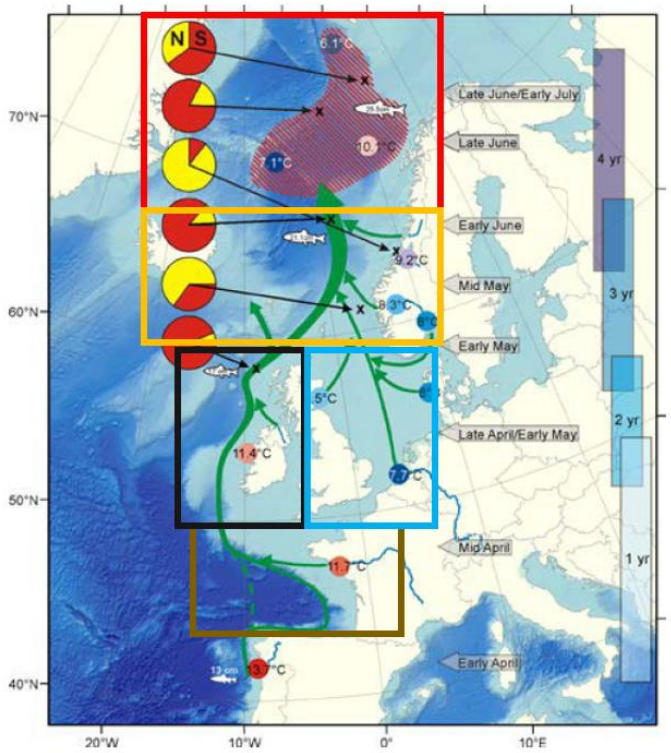
INTER-RIVERS COMPARISON

July-August/Sept

June-July

April June?
May June ?
Quid English? Fr ?

April-may



April-June?
May-June ?
Quid Engl ? FR ?

PhD project SAMARCH: 2018-2021

Response of migratory salmonid populations to global changes

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INTER-RIVERS COMPARISON

WHAT IMPACTS ON POPULATIONS DYNAMICS AND RESILIENCE ?

WP3
Toward Salmonid Stock Assessment Models


Marie Nevoux


Etienne Rivot


Guillaume Evanno


Ludivine Lamireau


Frédéric Marchand


Thibaut Jousseaume


Lisa Meslier


Anne-Laure Besnard


Sophie Launey


Jean-Marc Roussel


Maxime Olmos


Violette Silve

Thank you !

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