INTERNATIONAL SYMPOSIUM ON SMALL PELAGIC FISH:
NEW FRONTIERS IN SCIENCE FOR SUSTAINABLE MANAGEMENT
7 – 11 NOV. 2022

ENVIRONMENTAL EFFECTS ON SARDINE LARVAE IBERIAN PENINSULA

(SARDINE PILCHARDUS, WALBUM 1792)
- SOMATIC & OTOLITH GROWTH -

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REPÚBLICA PORTUGUESA MAR
Cofinanciado por: mar 2020 PROGRAMA OPERACIONAL MAR 2020
PORTUGAL 2020
UNIÃO EUROPEIA Fundo Europeu dos Assuntos Marítimos e das Pescas
sardinha 2020
IPMA

sardinha 2020

ABOUT SARDINHA 2020 PROJECT

Environmental Effects on Sardine larvae (this study) was developed within the scope of the project “Sardinha 2020”, being implemented by the Instituto Português do Mar e da Atmosfera (IPMA), and funded by Portugal 2020, Programa Operacional Mar 2020 and European Union.

MAIN GOALS OF SARDINHA 2020

Sardinha 2020 project aims to develop a management plan fishing industry paring with the guidelines of the EU Common Fisheries Policy (PCP) and the Marine Strategy Framework Directive.

The development of the project involves an extended and very specialized team, which I am very proud to make part, that carries out studies on the biology, habitat and stock of pelagic species, such as sardines and anchovy.

Small Pelagic Fishes (SPF) are key species of the Ibero-Atlantic ecosystem, because they support the integrity of marine food webs and ensure a valuable food resource for Human communities. As known, SPF stocks are susceptible to periodic collapses dramatically affecting the ecological and human communities.

"These periodical fluctuations have as a rule been of some considerable duration, a series of years of profitable fishery succeeding and succeeded by several years of dearth."

(Hjort, 1914, p. 3)

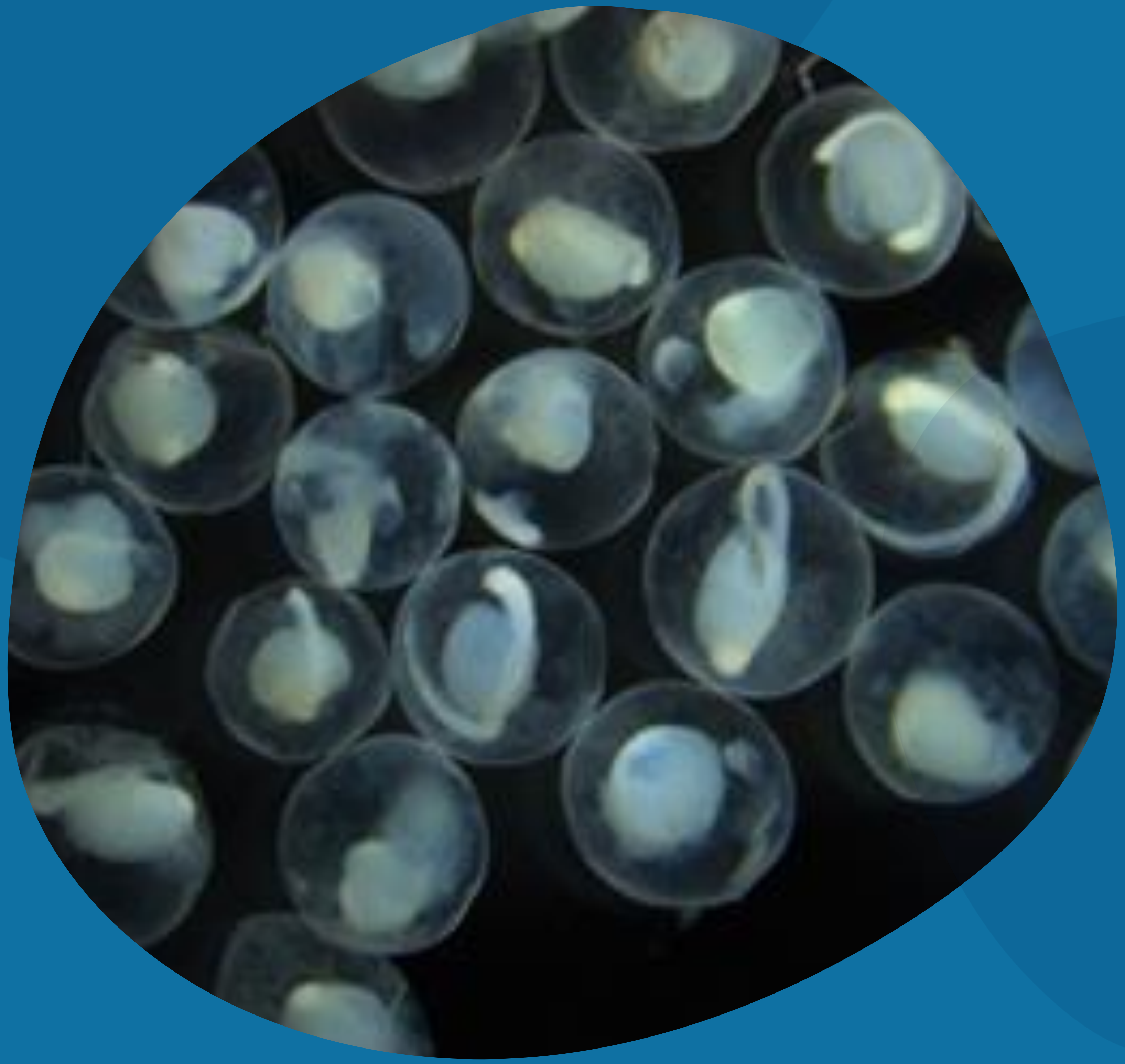
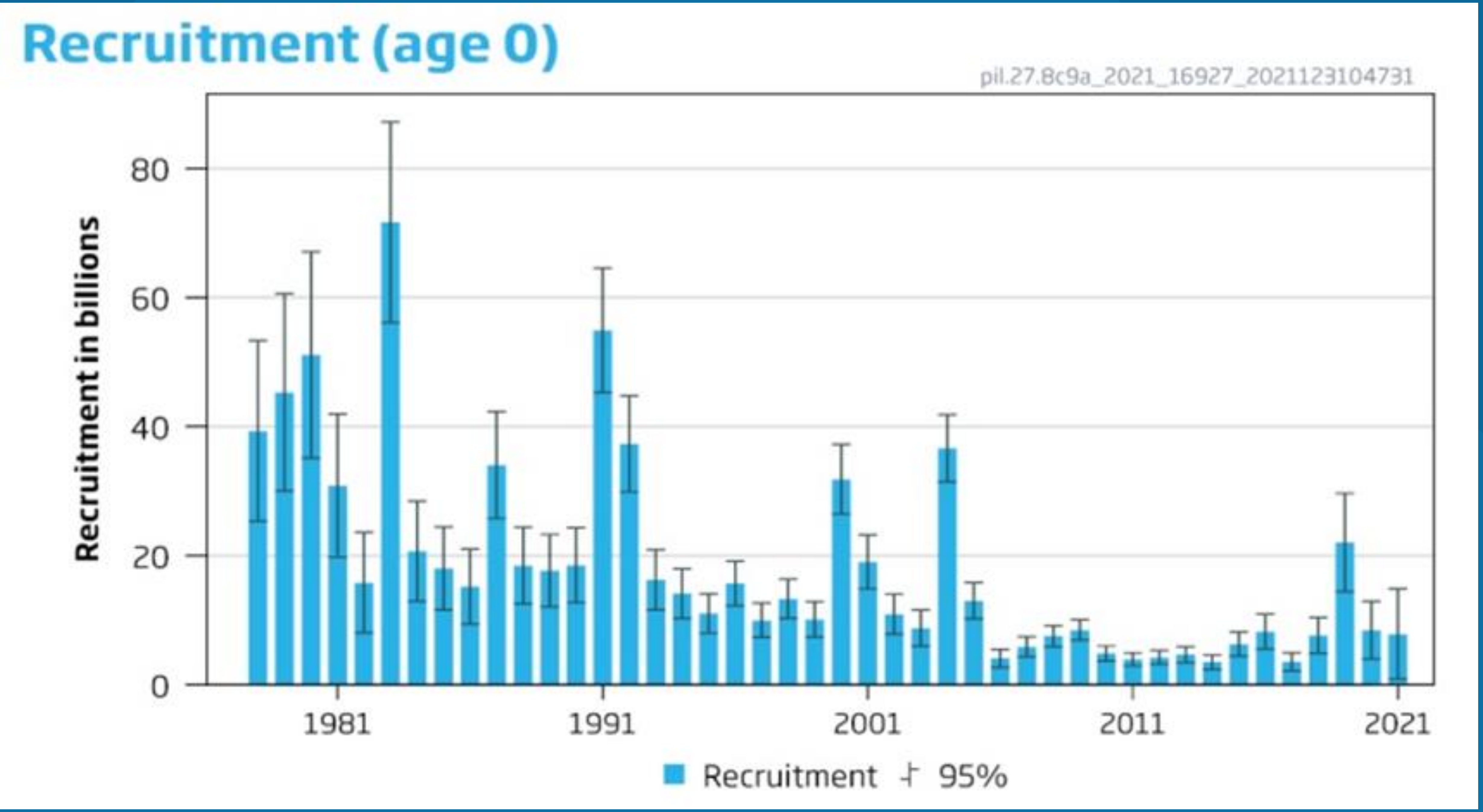


Photo by S.Antunes

TWO PREMISES ARE STABLISHED BY THE SCIENTIFIC COMMUNITY:

- The variability of the stocks due to the annual success in the recruitment of the species that is to the survival in the first stages of life.
- The survival of this first stages of life is dependent of the environmental conditions.

In recent decades, there has been a steady decline in historical levels of Ibero-Atlantic Sardine biomass, despite the low fishing mortality, and, we know, this down-grade it is extensible to the recruitment levels.



ICES 2022

To study the dynamics of Ibero-Atlantic populations we have to know how the sardines larvae survives until reach out the recruitment age.

1) we have to monitor the distribution of eggs and larval stages of Ibero-Atlantic sardine, at beginning and end of the spawning season;

2) also, we have analyse the growth and nutritional condition of the larval stages;

(c) and, finally, we have to consider the relation of the distribution, growth and nutritional condition of larvae with environmental factors.

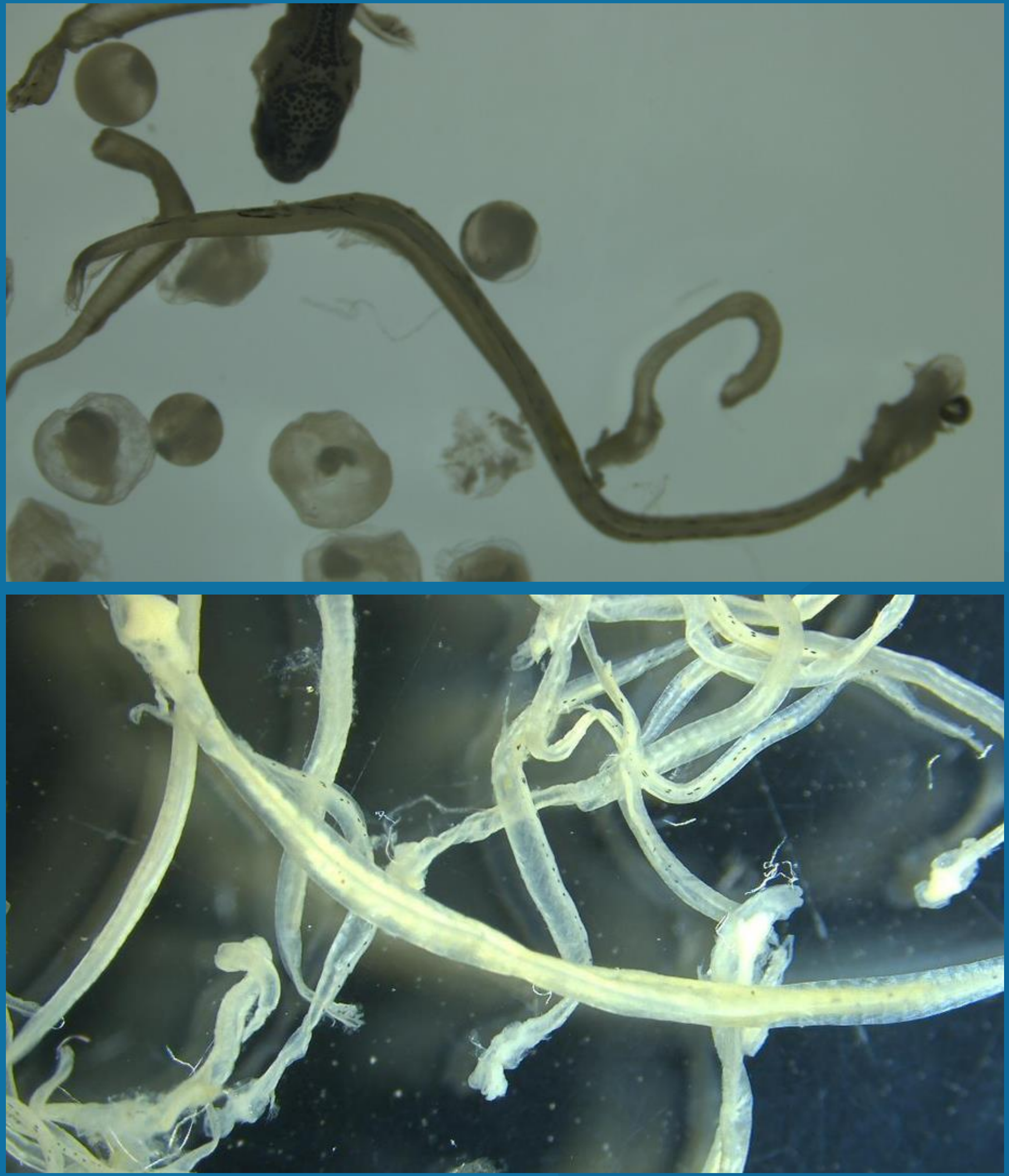
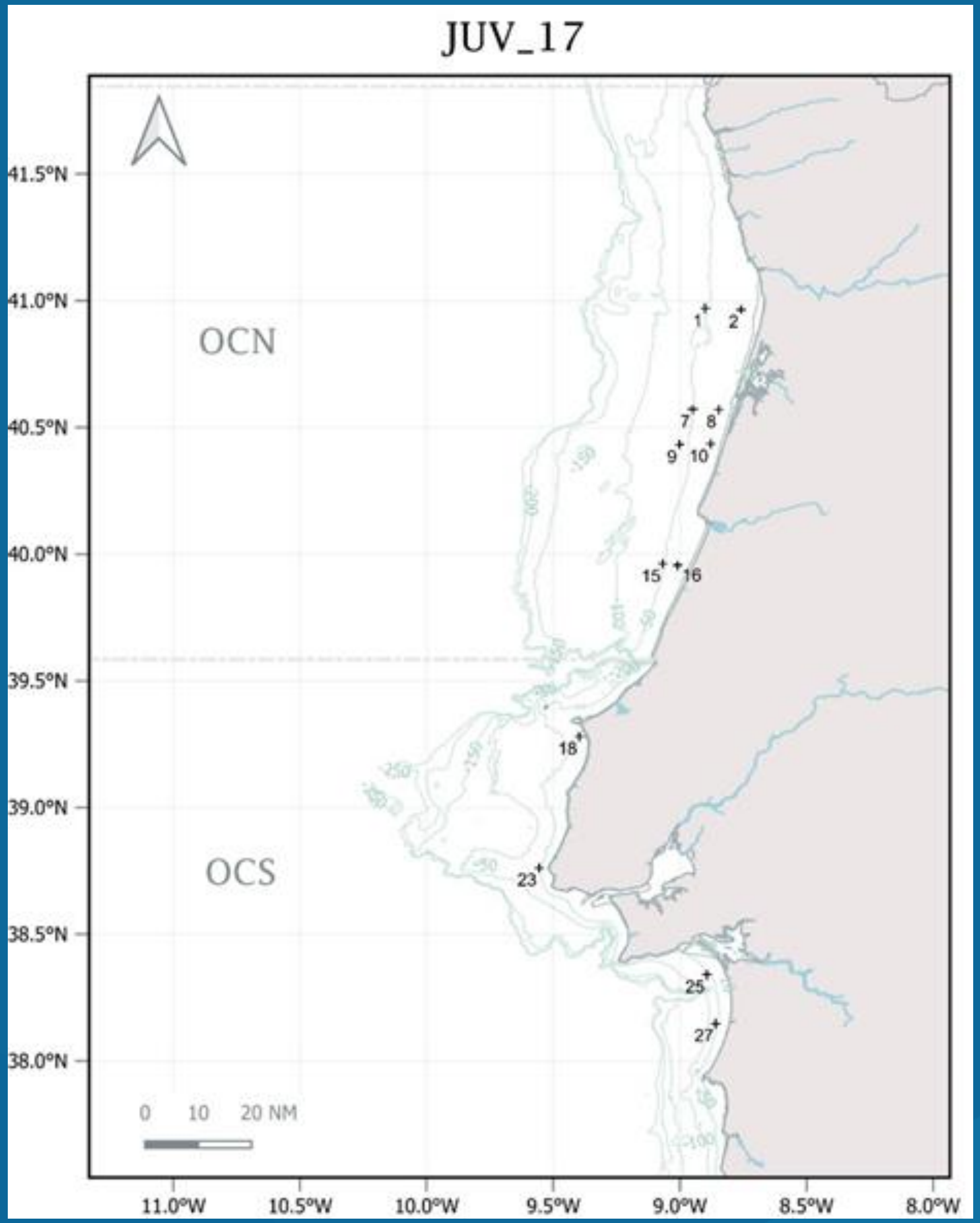


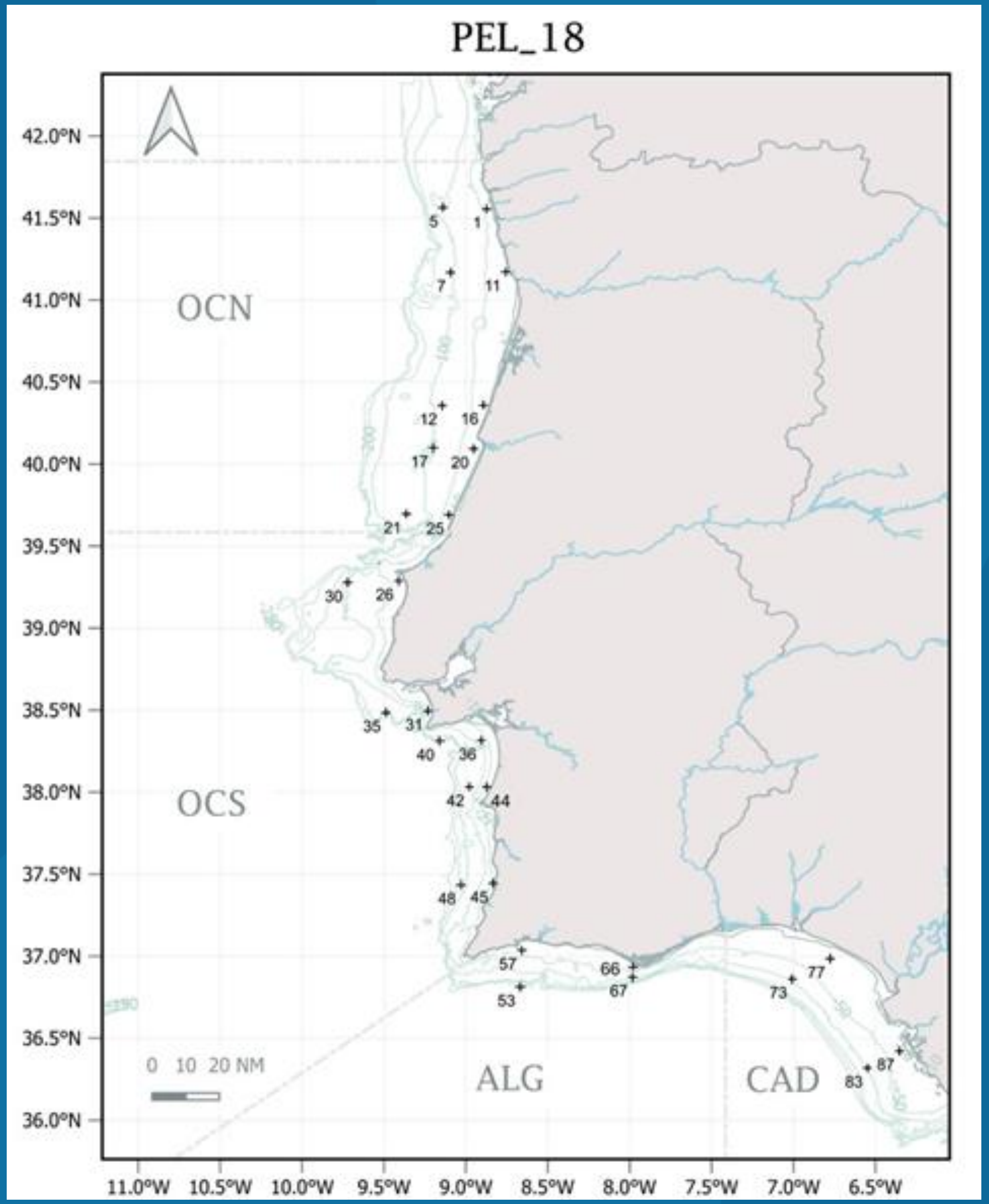
Photo by S.Antunes

THE PROCESS...

a) Samples were collected in late autumn 2017 and early spring 2018, covering the beginning and end of the Sardine spawning season:



4th trimester Autumn 2017



2nd trimester Spring 2018

THE PROCESS...

b) Fish larvae were caught using BONGO nets and the samples were immediately preserved in alcohol 96%;

c) While sampling was taking place, we use a Conductivity Temperature and Depth/pressure (CTD) to collect the oceanographic data.

Photo by Dina Silva

BONGO nets

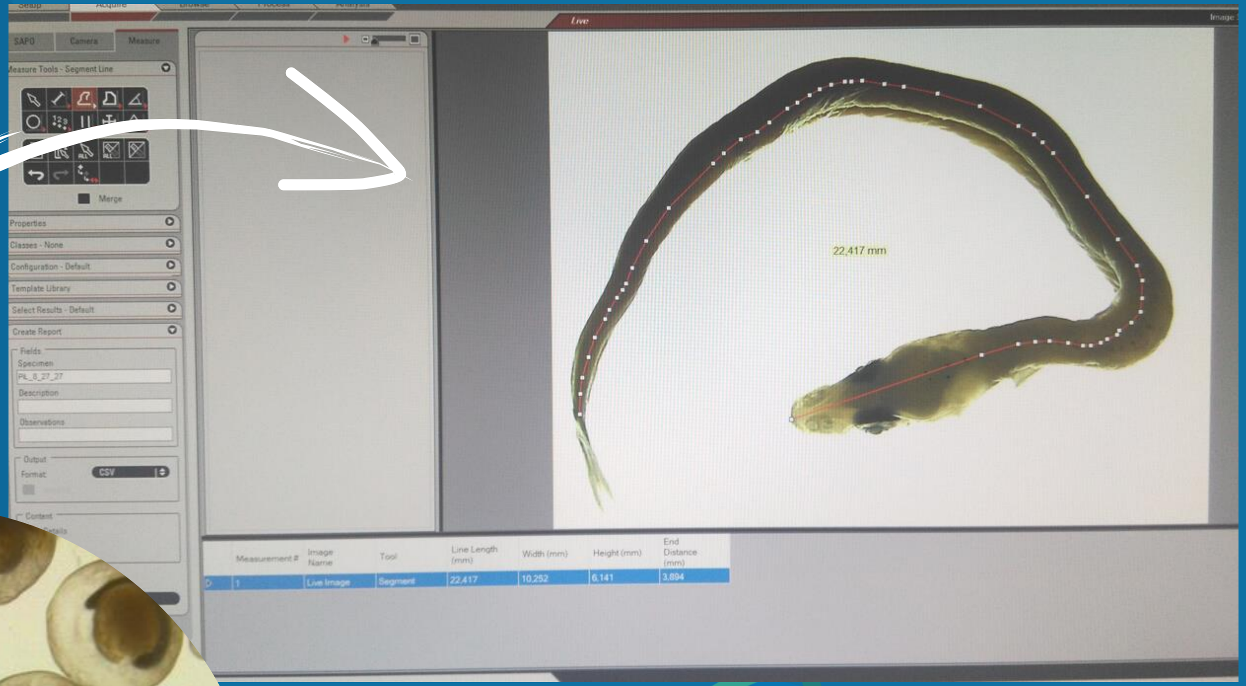
Photo by Ana Moreno

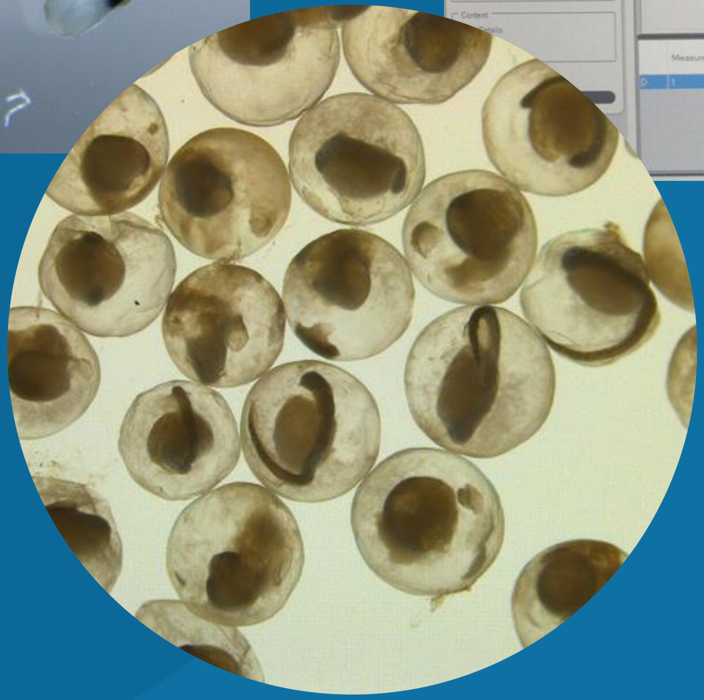
CTD

Photo by S.Antunes

Alcohol Conservation (96%)

IN THE LAB





Otolith removal

DNA/mg quantification

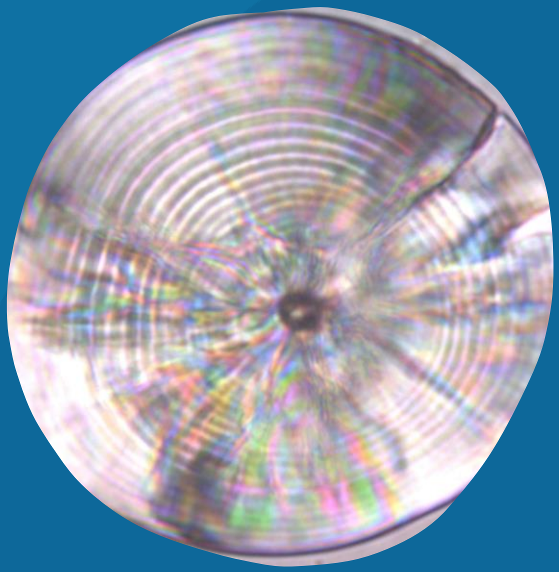
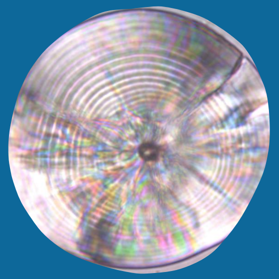
Photos by S.Antunes

IN THE LAB

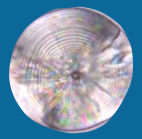
Fotos by S.Antunes

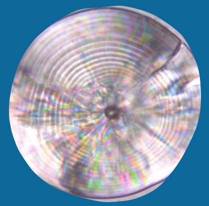
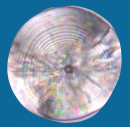
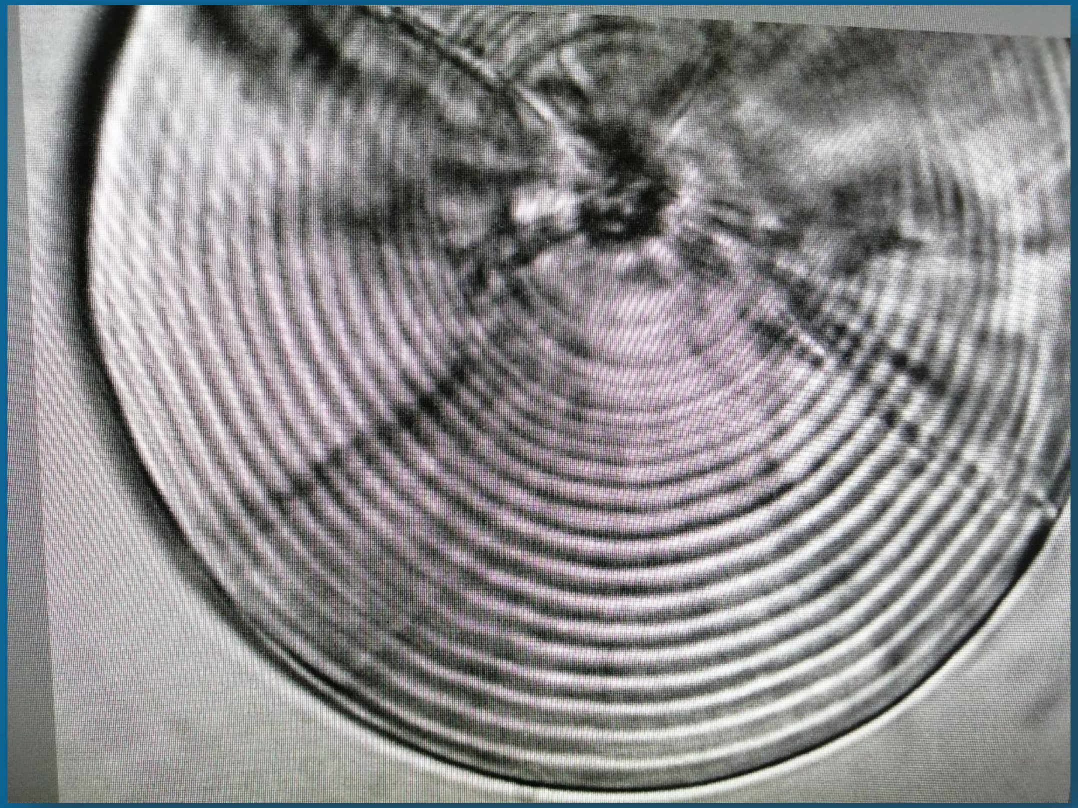
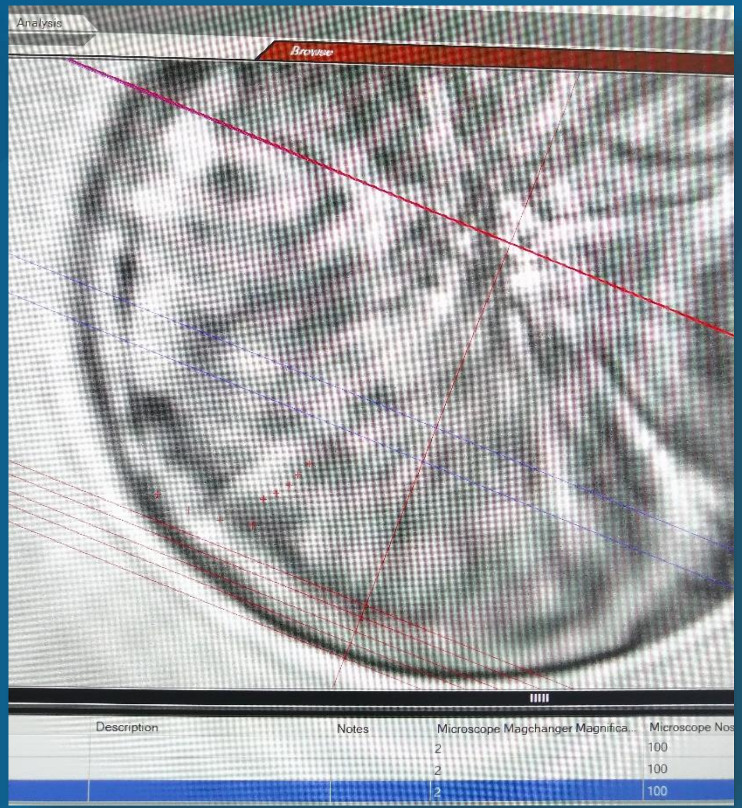
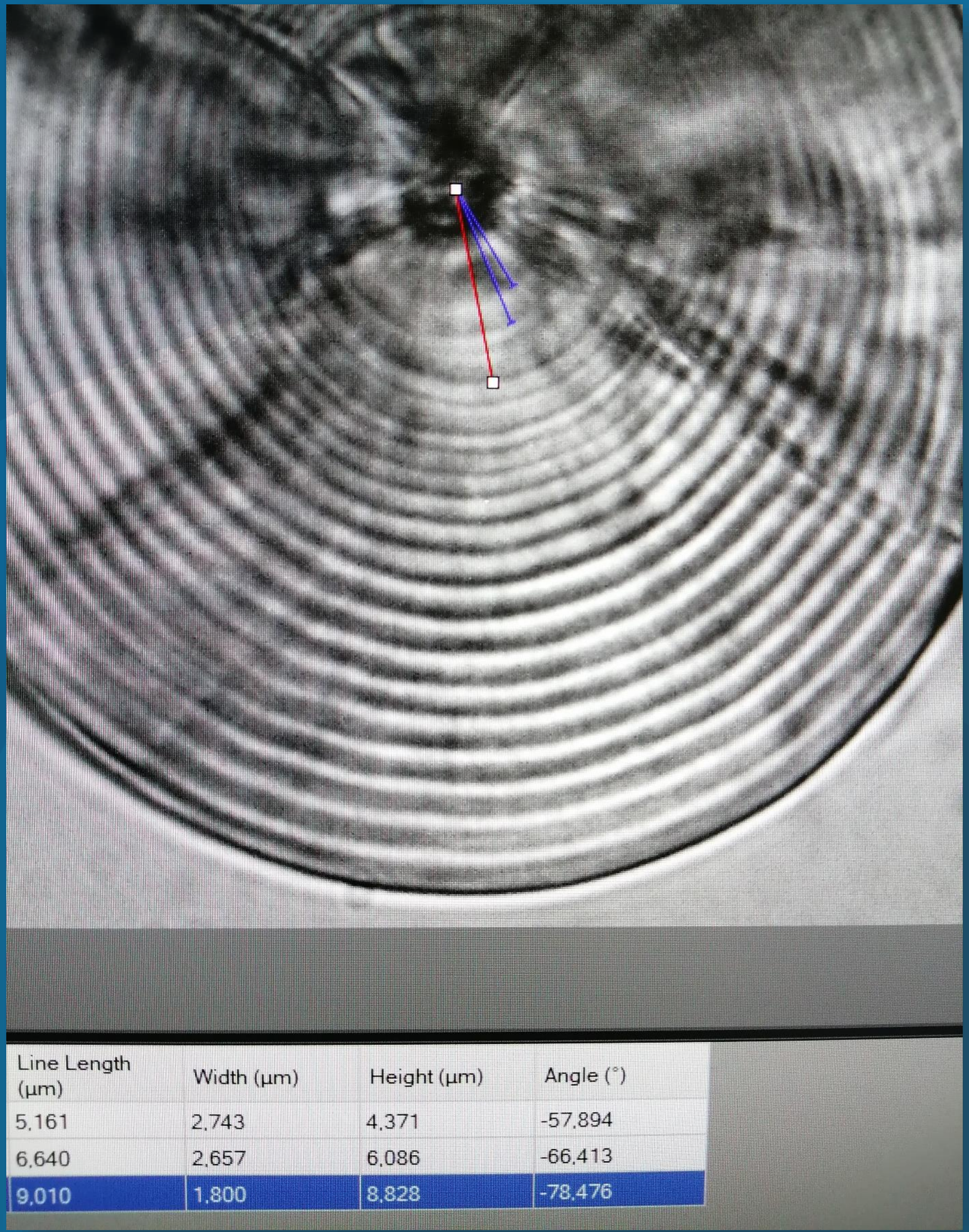
Otolith removal

IN THE LAB





Photos by S.Antunes

Otolith measurement

ANALYTICAL METHODS...

- **‘R’ software** to get to the one that best describes somatic growth;

- The Larvae Distribution, Sea Surface Temperature (SST) and Chlorophyll-a maps were created in the **QGis 3.14** program.

- **Generalized Additive Models (GAM’s)** were used to explore the effect of environmental variables on sardine larvae density, growth rate, larvae condition (DNA/mg) and growth of the last three otolith rings:

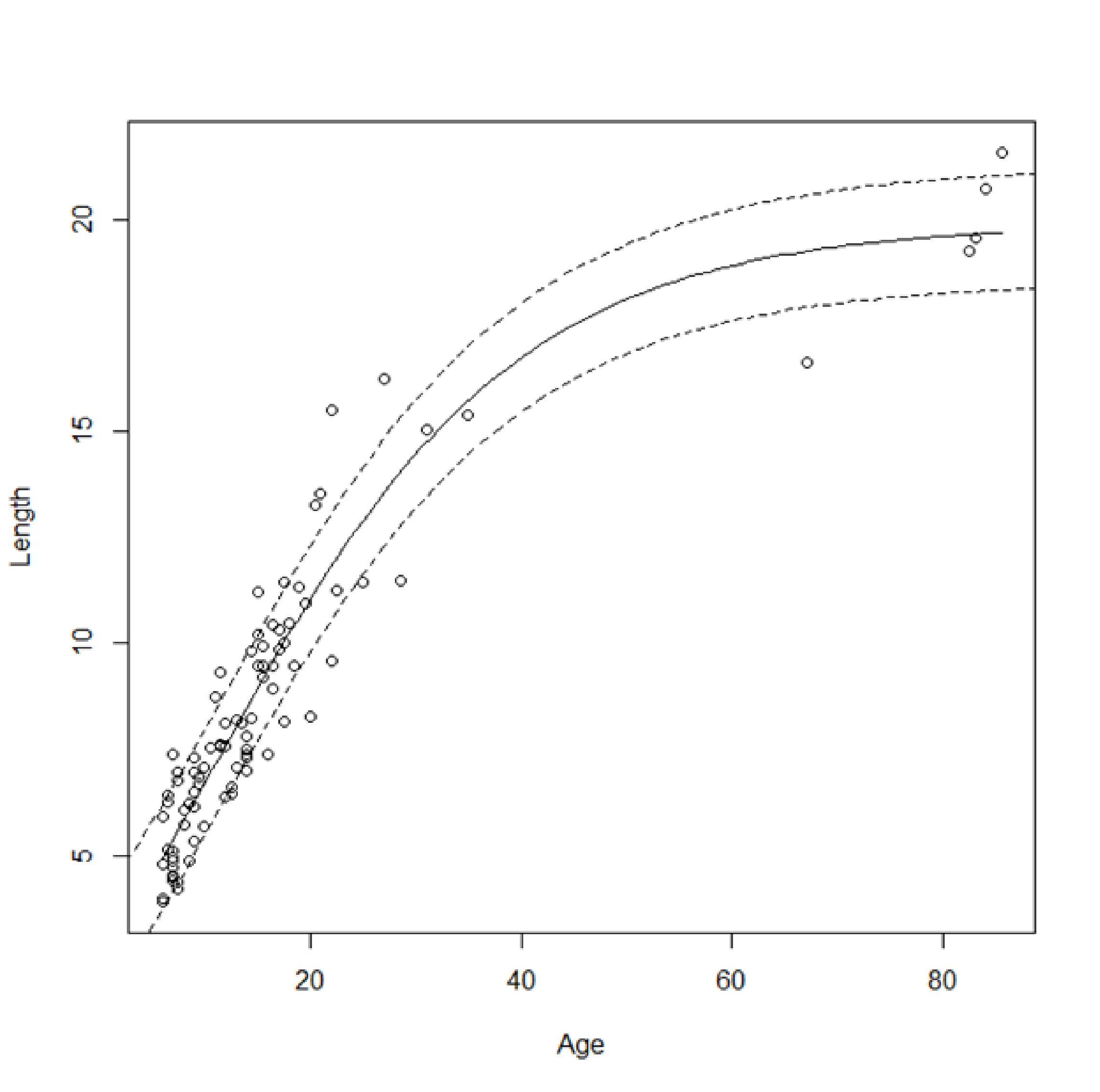
  - Models were selected sequentially removing explanatory variables with nonsignificant partial effects or the less significant.

LET'S SEE SOME DATA RESULTS...

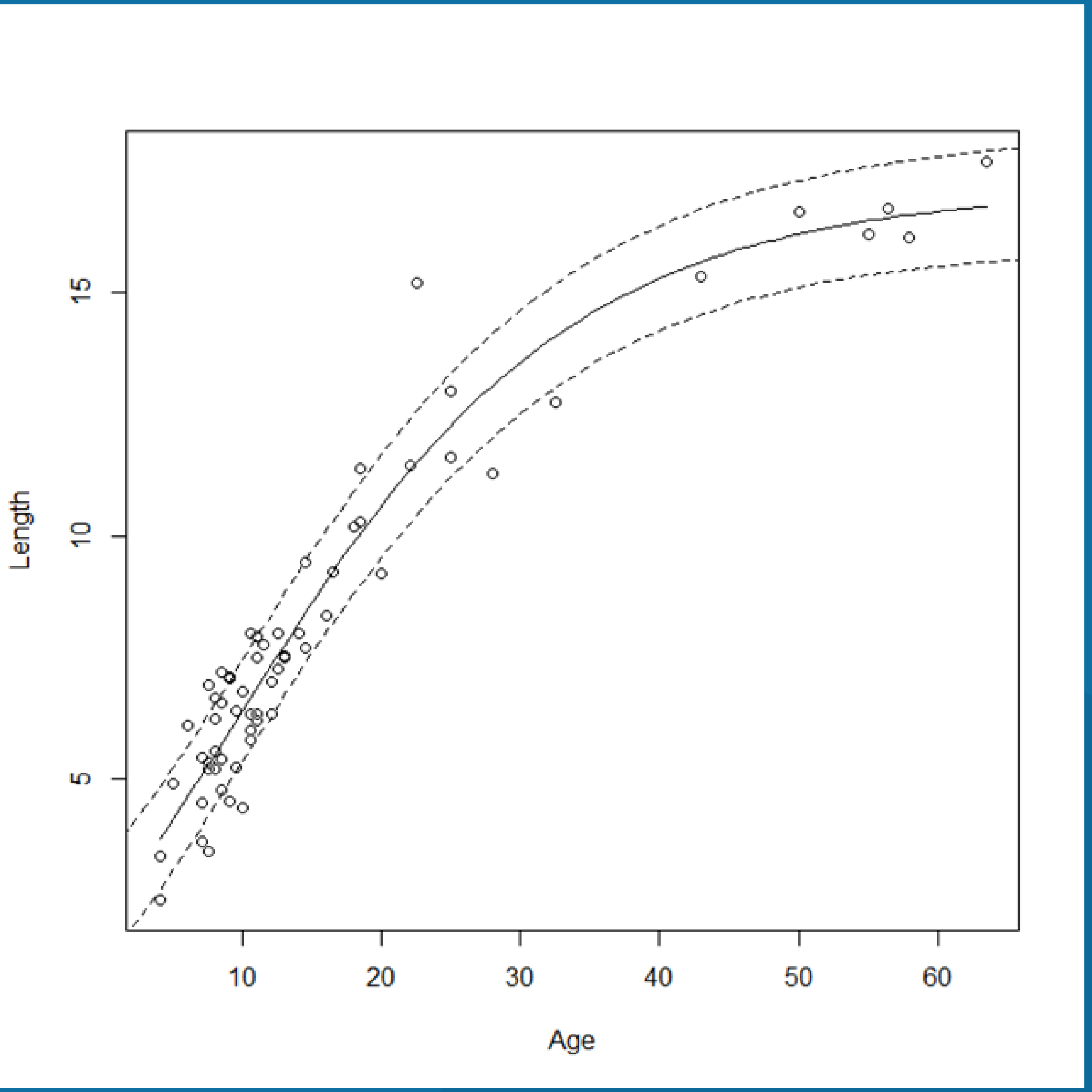
Growth curves

The Growth Rate it’s best described by the logarithmic model Laird-Gompertz (Garrido et, 2016).

$$L = L_0 e^{\left(\frac{A_0}{\alpha}\right)\left(1 - e^{(-\alpha^{*} t)}\right)}$$



Growth rate in Autunm:
0,611 mm/d



Growth rate in Spring:
0,593 mm/d

LET'S SEE SOME DATA RESULTS...

- Larvae density

Larvae were observed north to south throughout the surveyed area, but mainly concentrated from the coast until 100 m, as you can see in the maps.

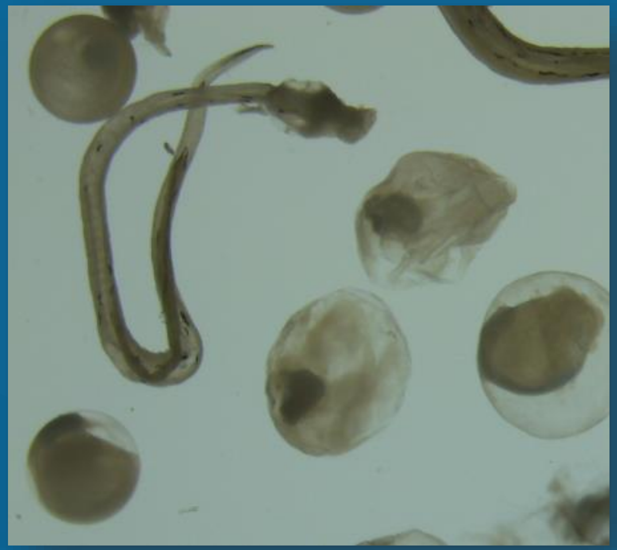
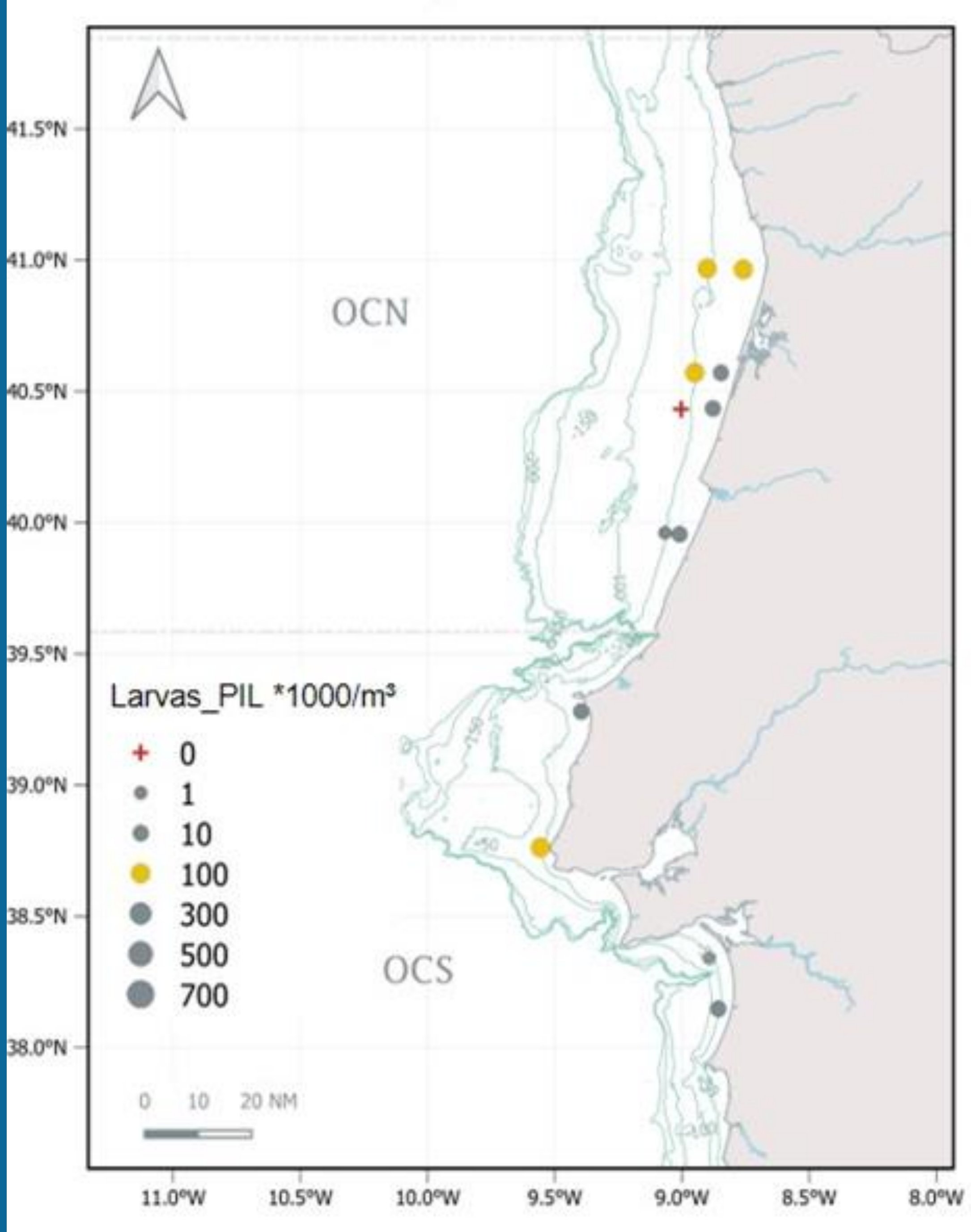
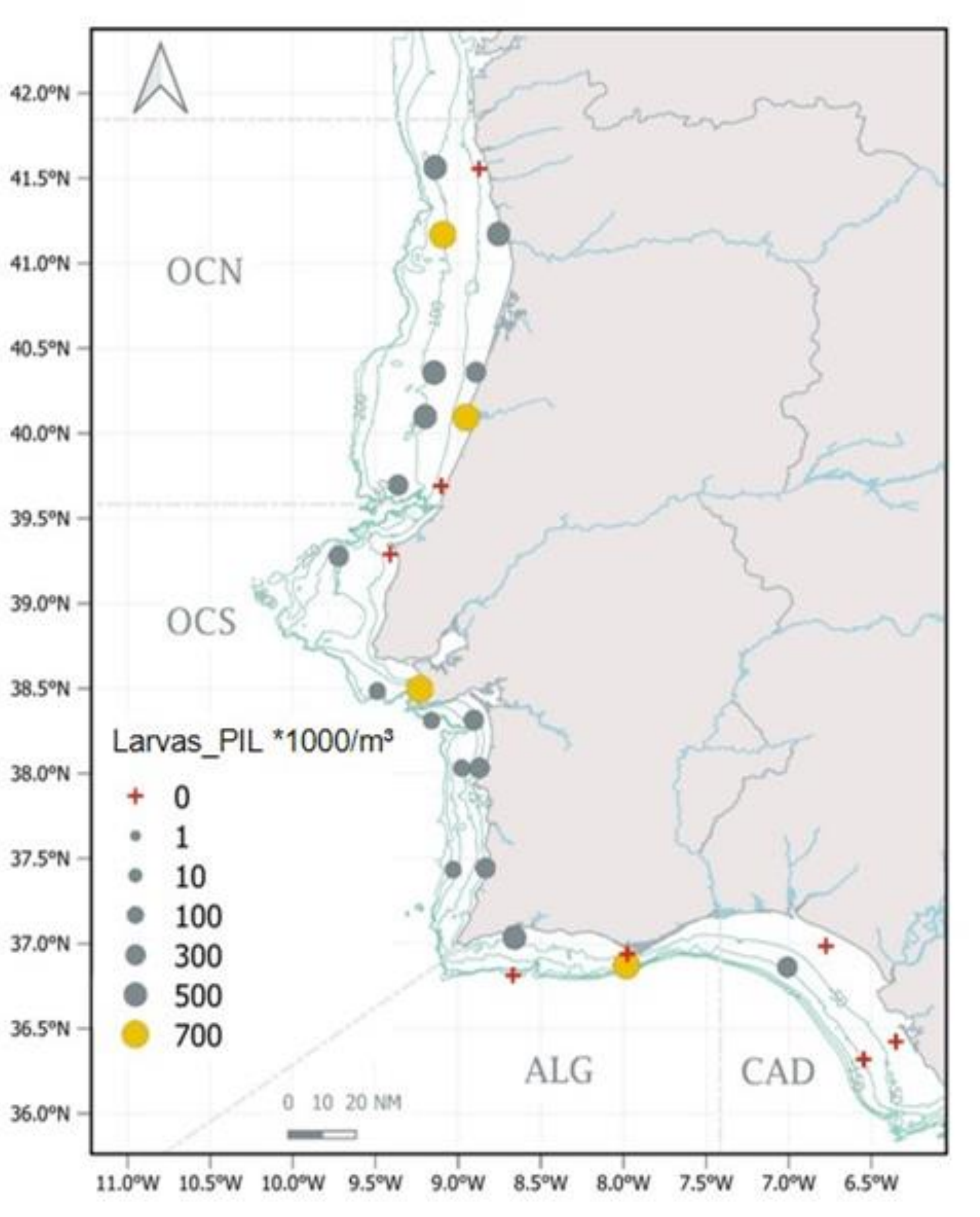


Photo by S.Antunes



Autumn
Beginning of spawning season



Spring
End of spawning season

Larvae and Eggs Occurrences

LET'S SEE SOME DATA RESULTS...

- **Egg density**

The occurrence of eggs was very low in autumn and much more abundant on the west coast in the spring

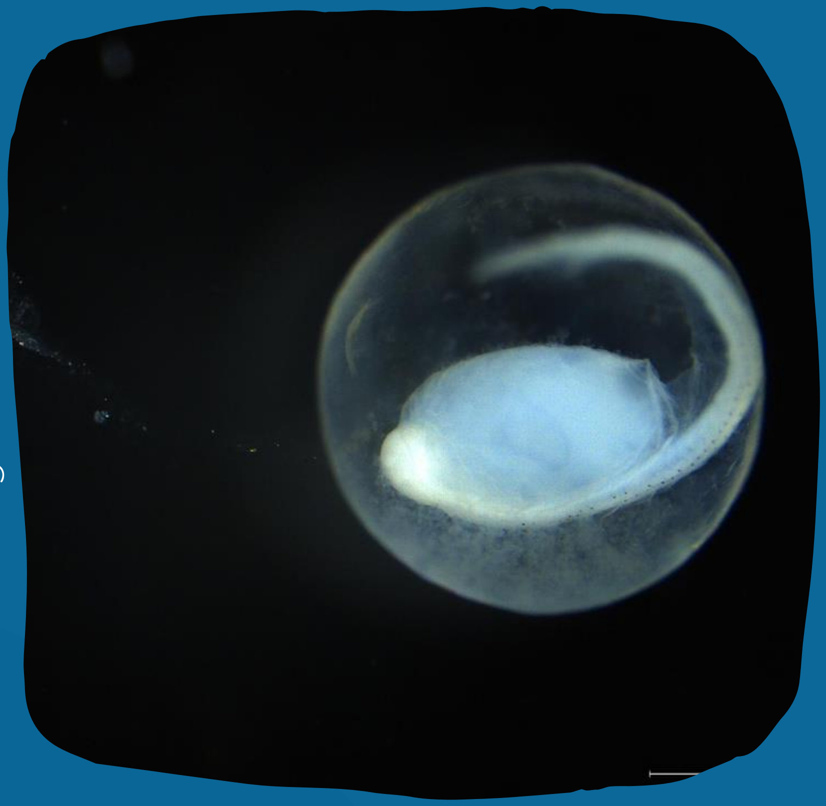
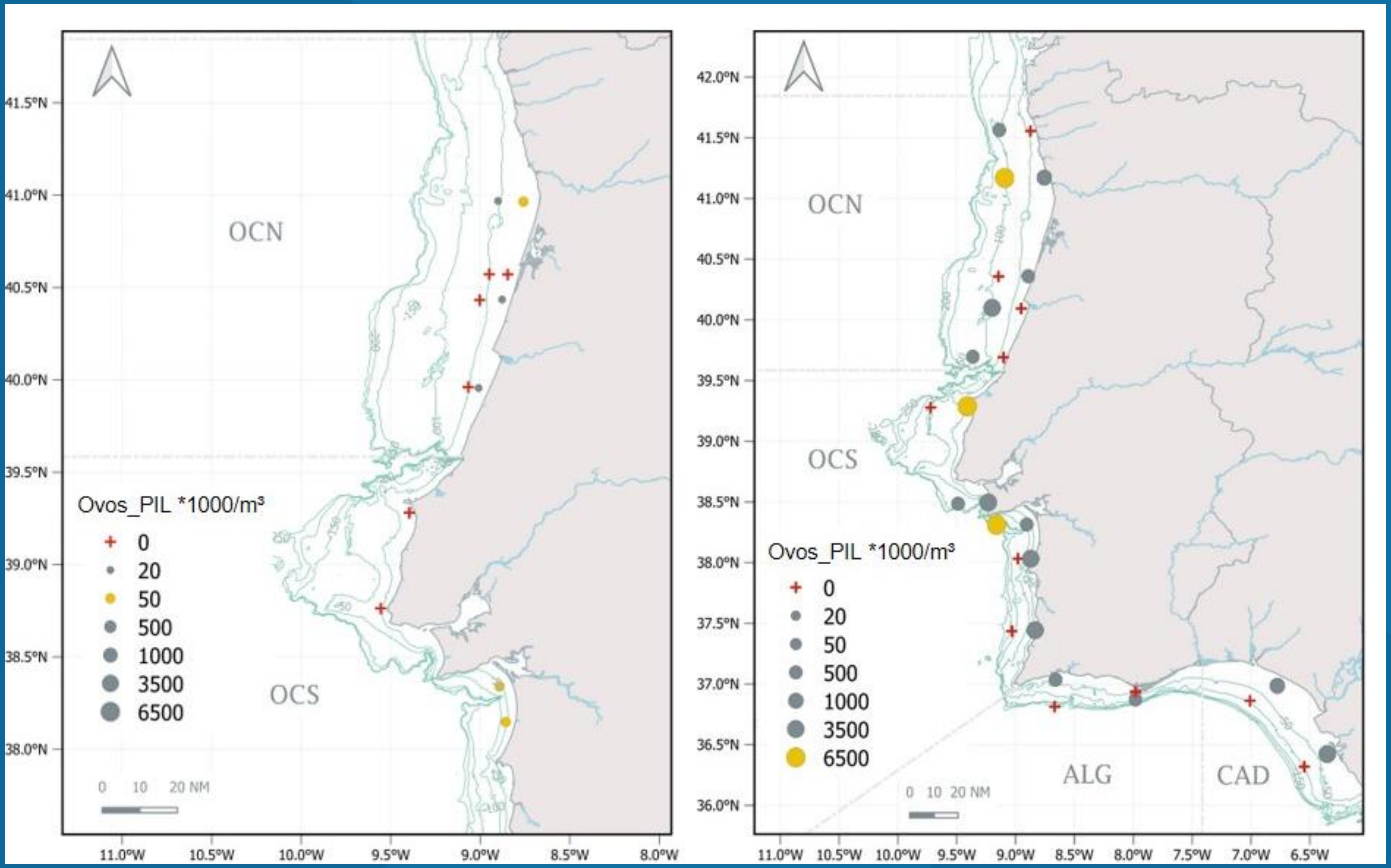


Photo by S.Antunes



Autumn
Beginning of spawning season

Spring
End of spawning season

Larvae and Eggs Occurrences

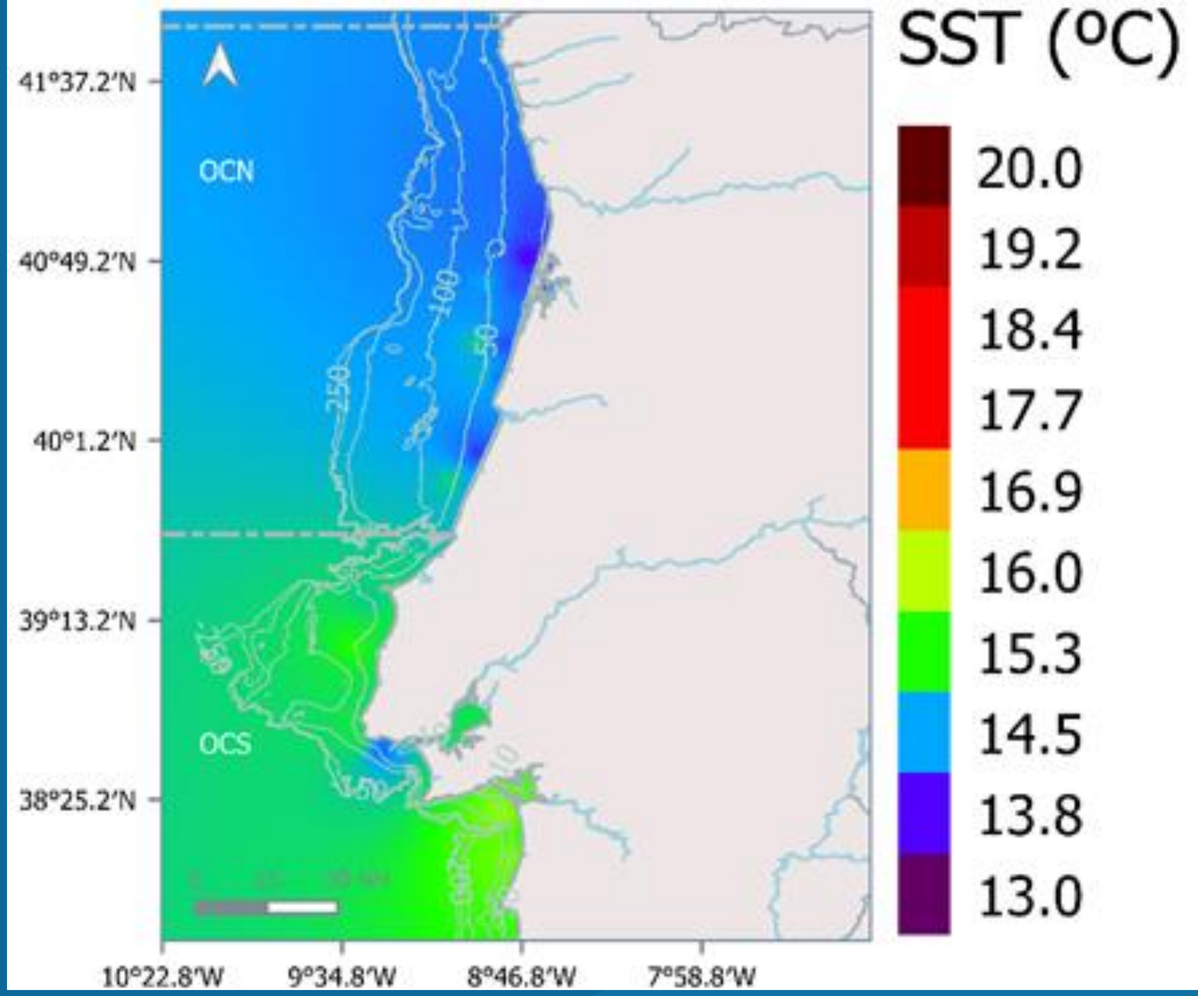
LET'S SEE SOME DATA RESULTS...

Sea Surface Temperature (SST)

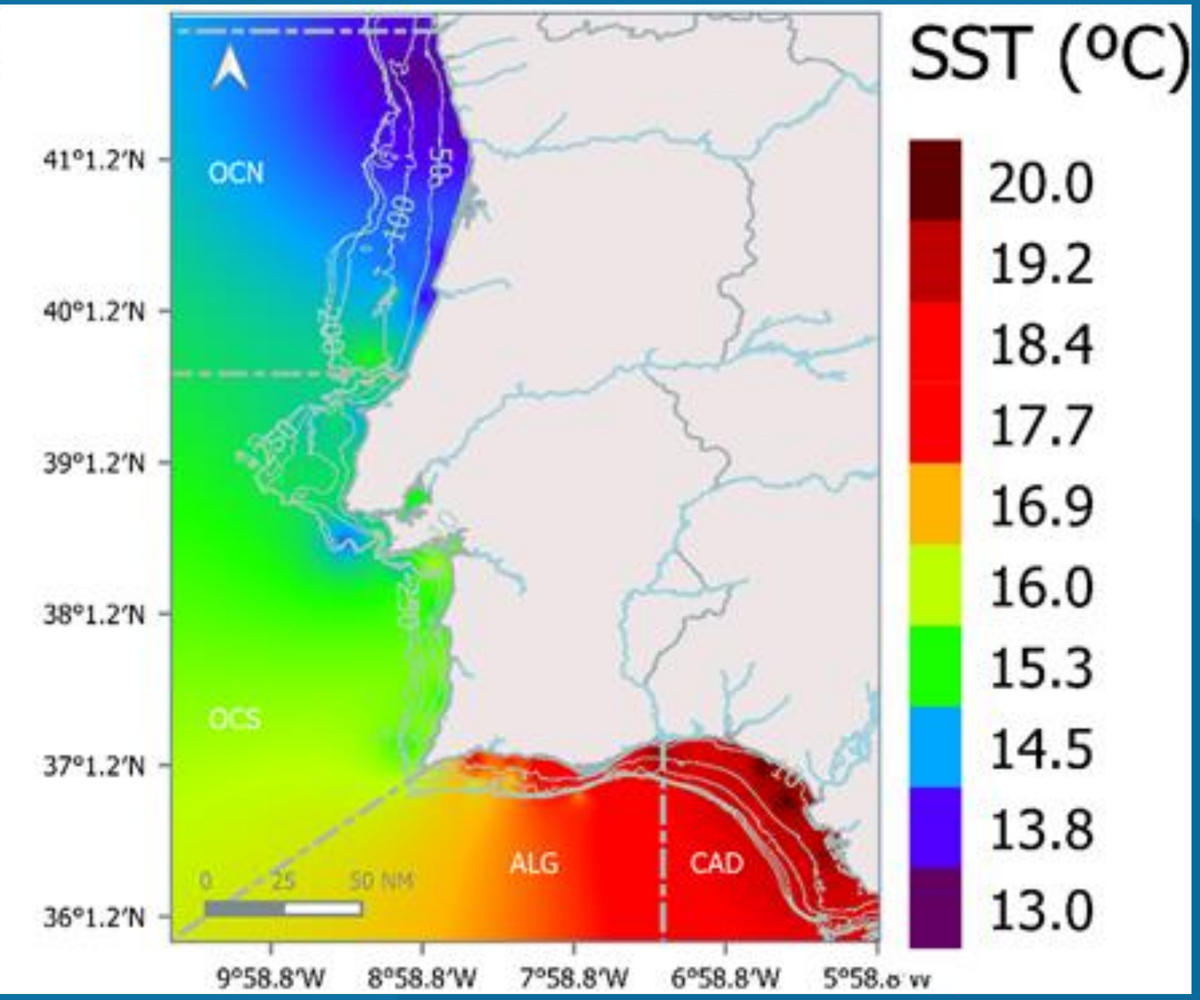
- The south coast has a much higher temperature, with differences of more than 5ºC

- In autumn the temperatures were typical for this time of year.

- In spring, temperatures on the north coast were lower than in previous years.



Autumn
Beginning of spawning season



Spring
End of spawning season

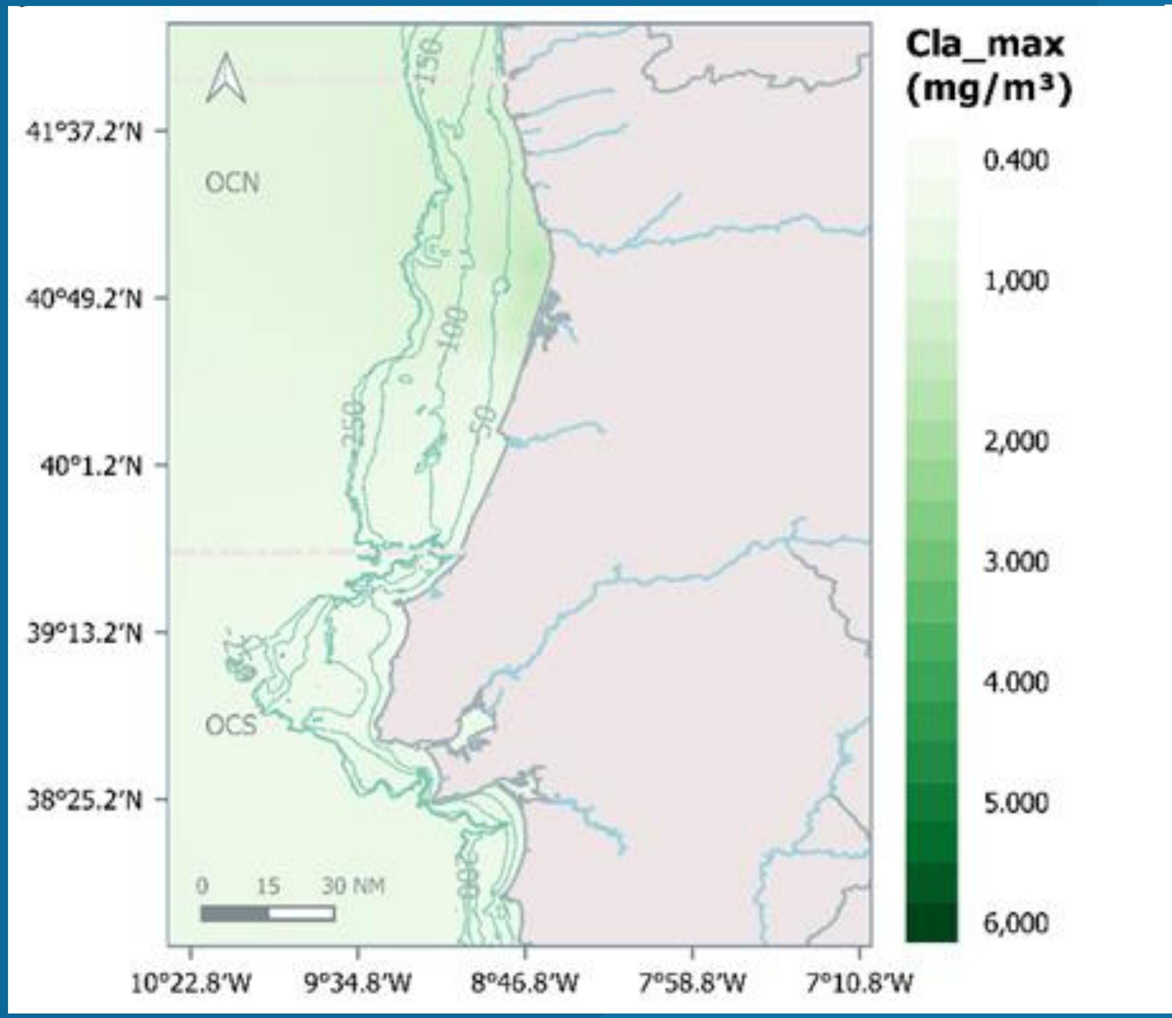
LET'S SEE SOME DATA RESULTS...

The availability, size and type of food are crucial to ensure rapid growth and survival.

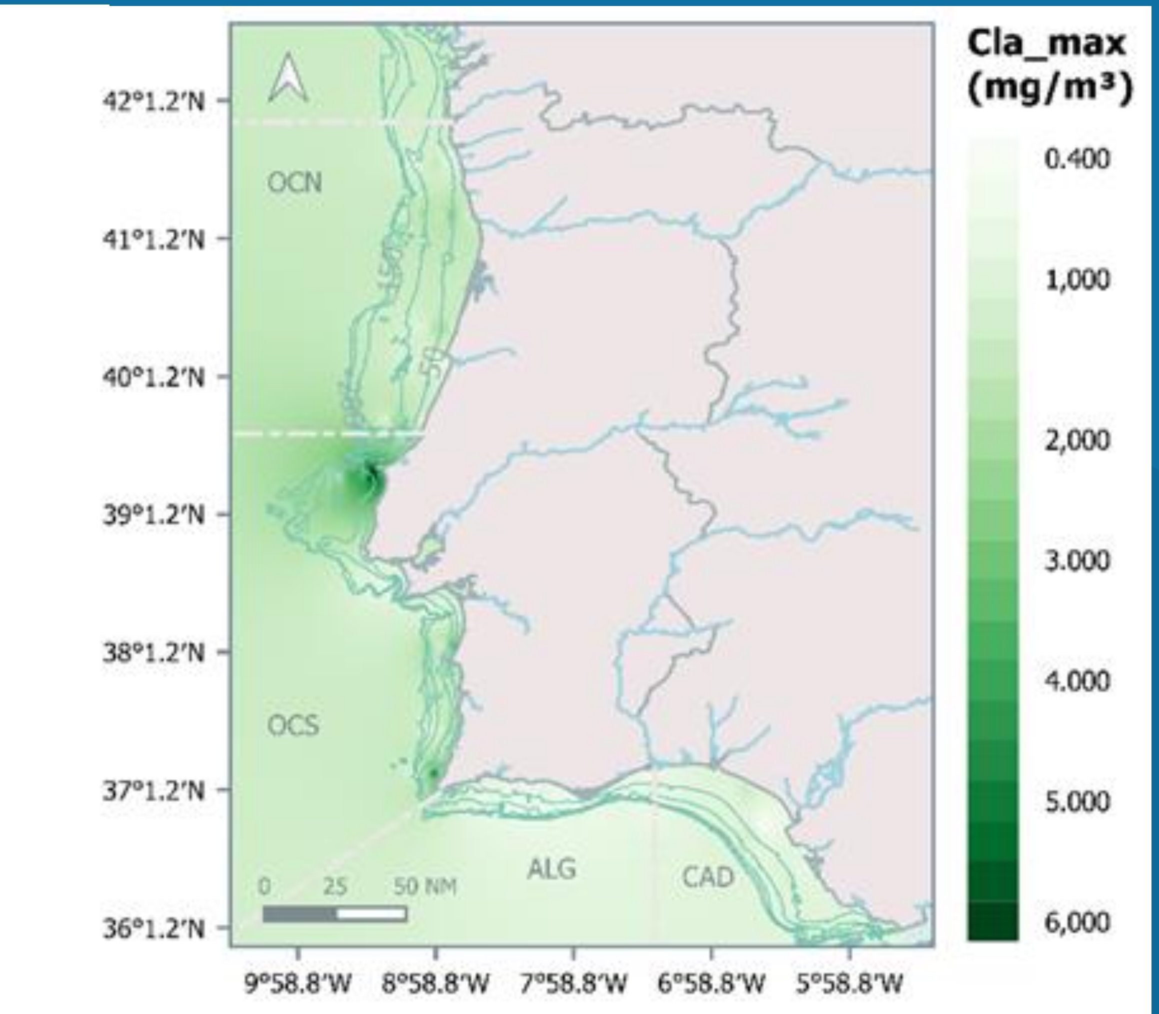
Photos by S.Antunes

The highest chlorophyll values were observed in the spring on the northwest coast.

Chlorophyll-a (maximum)



Autumn
Beginning of spawning season



Spring
End of spawning season

LET'S SEE SOME DATA RESULTS...

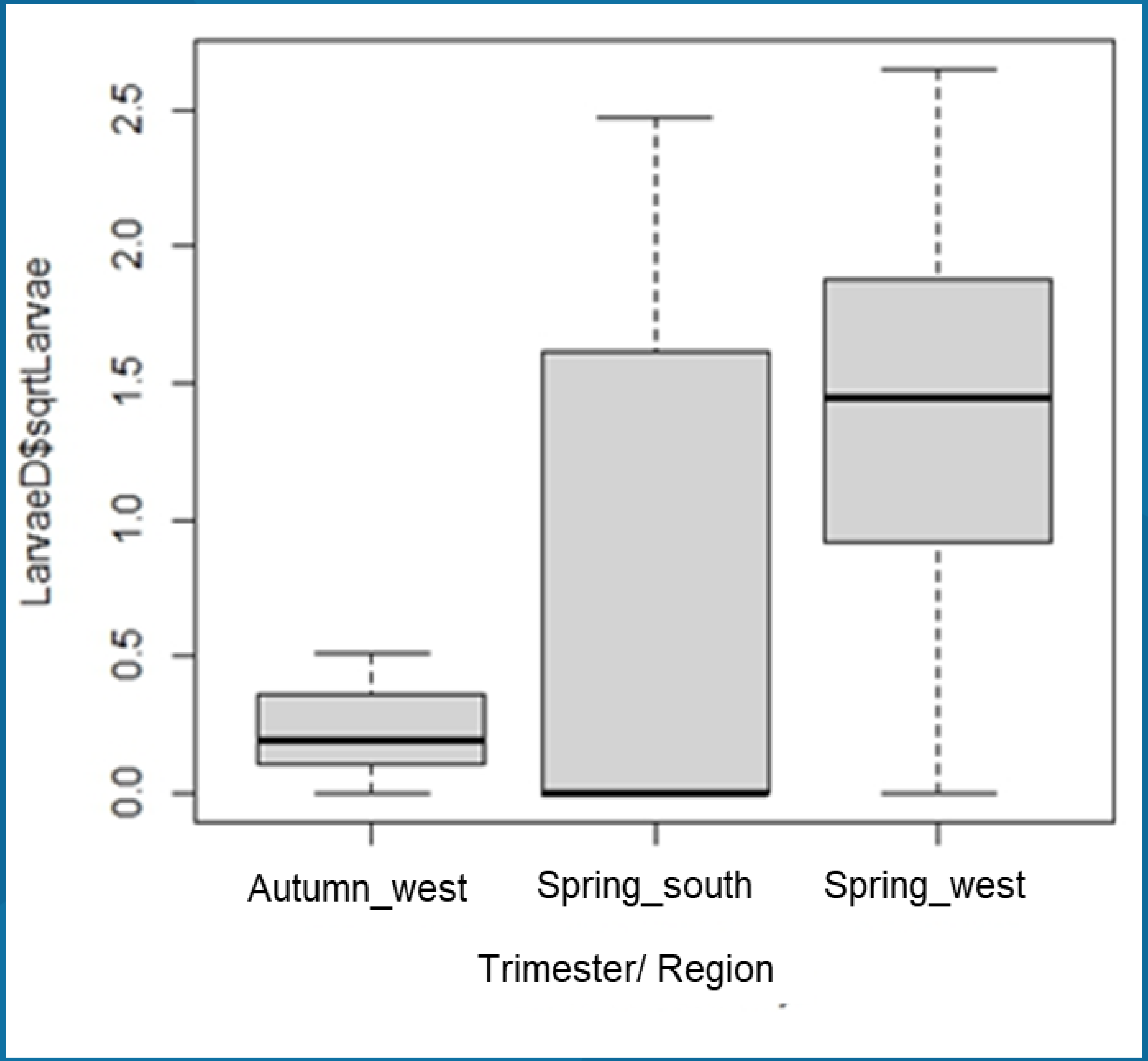
GAM's Larvae Density

Best fitted model: sqrtLarvae ~ as.factor(Trimester/ Region) + s(Bdepth, k = 5) + s(SST, k = 5) + s(sqrtEggs, k = 5)

Deviance explained = 65,6%

The results suggest there is higher larvae density on the west than on the south.

On the west, density significantly higher at the end of the spawning season.

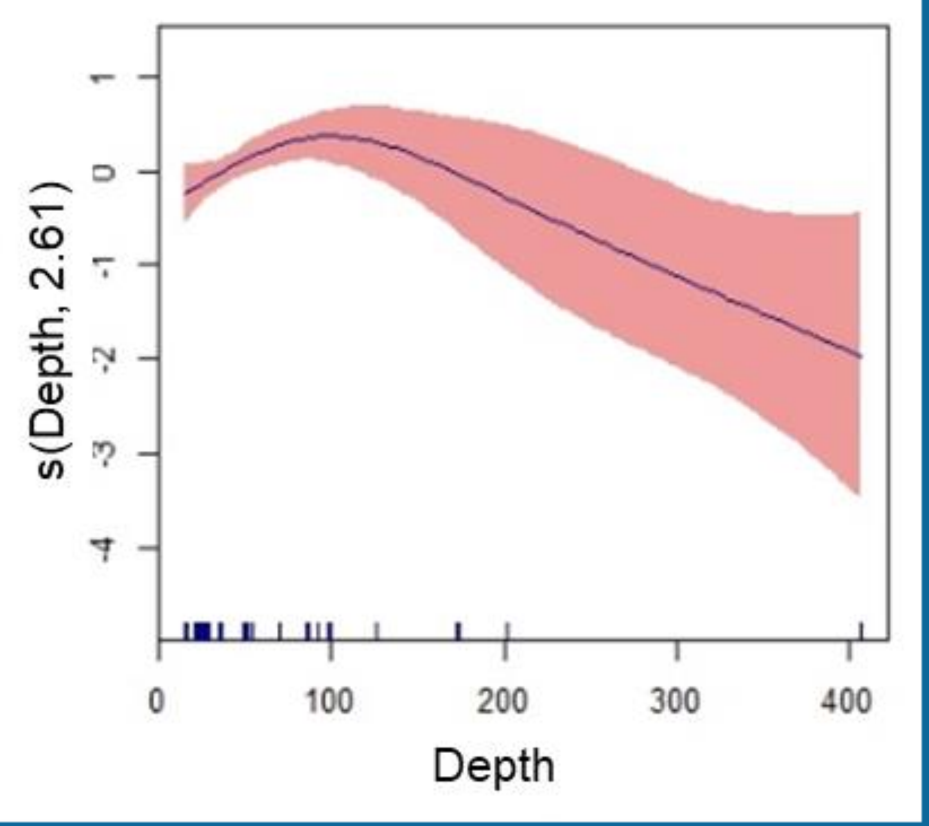


Nominal variables Trimester/ Region

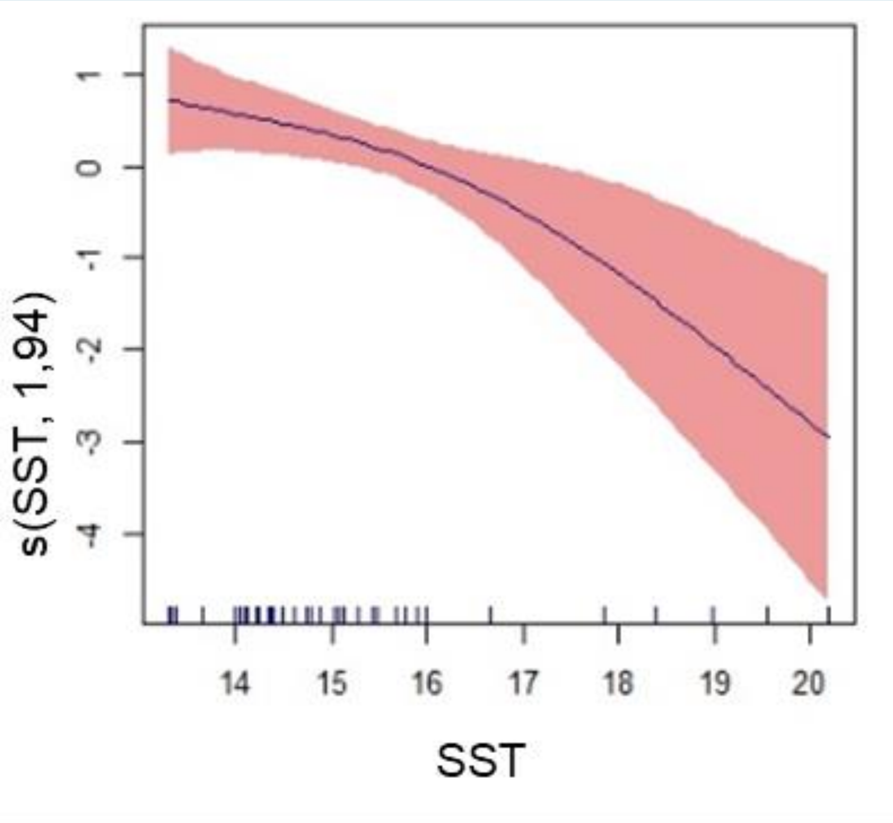
LET'S SEE SOME DATA RESULTS...

GAM’s Larvae Density

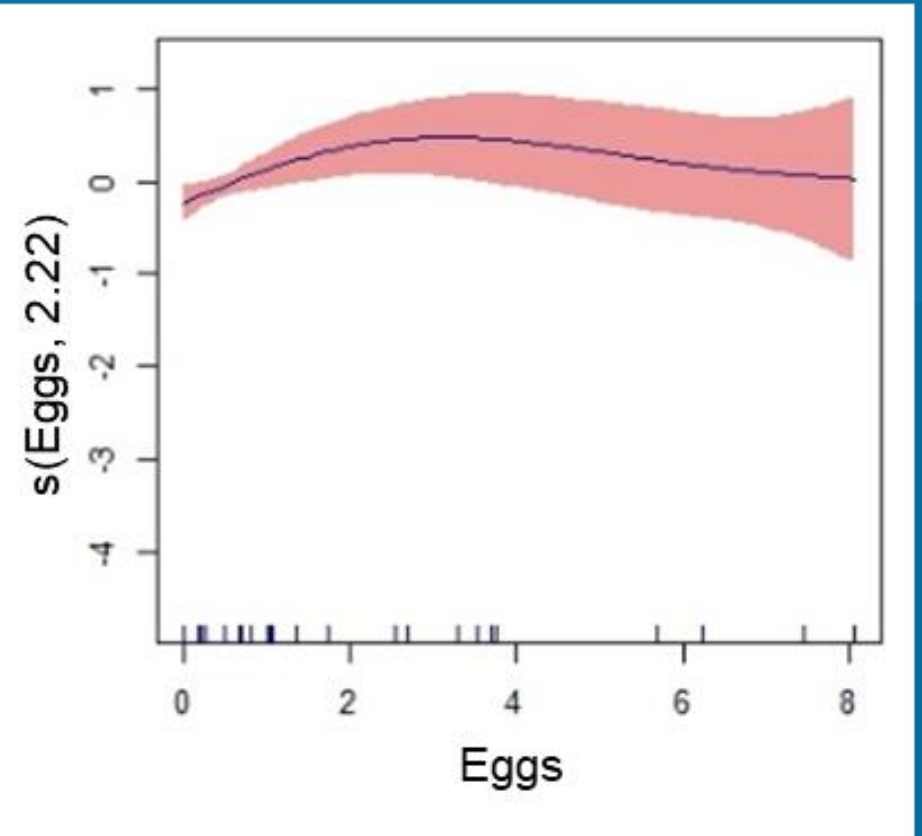
Environmental explanatory variables:



a) Depth



b) Sea Surface Temperature (SST)



c) Eggs

LET'S SEE SOME DATA RESULTS...

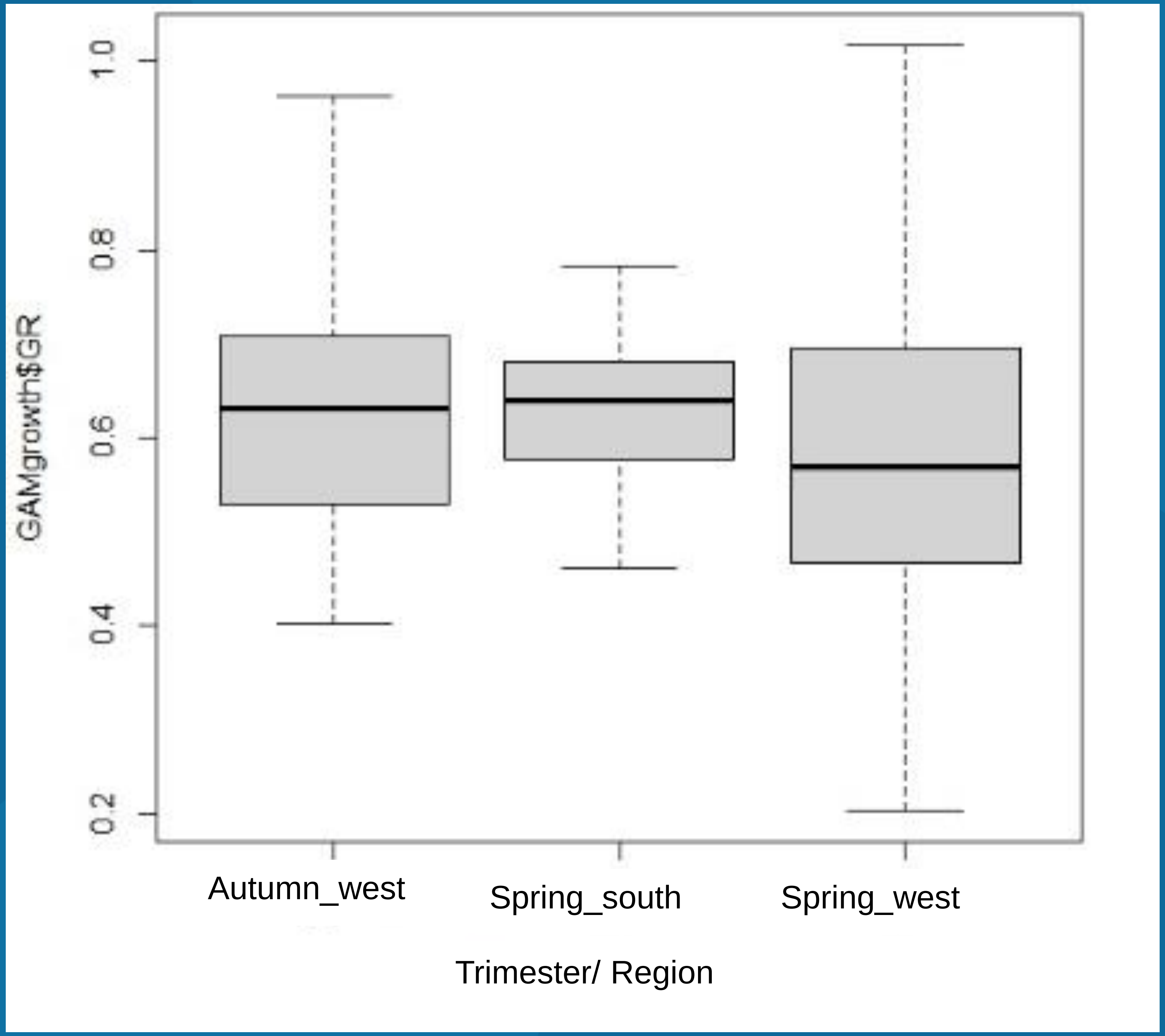
GAM’s Larvae Growth

Best fitted model: GR ~ as.factor(Trimester/ Region) + s(Chla_maxR, k = 5) + s(SST, k = 5) + s(sqrtLarvaeD, k = 5) + s(Length, k = 5)

Deviance explained = 61,4%

Higher growth rate on the south coast.

Lower growth rates on the west coast in Spring than in Autumn.



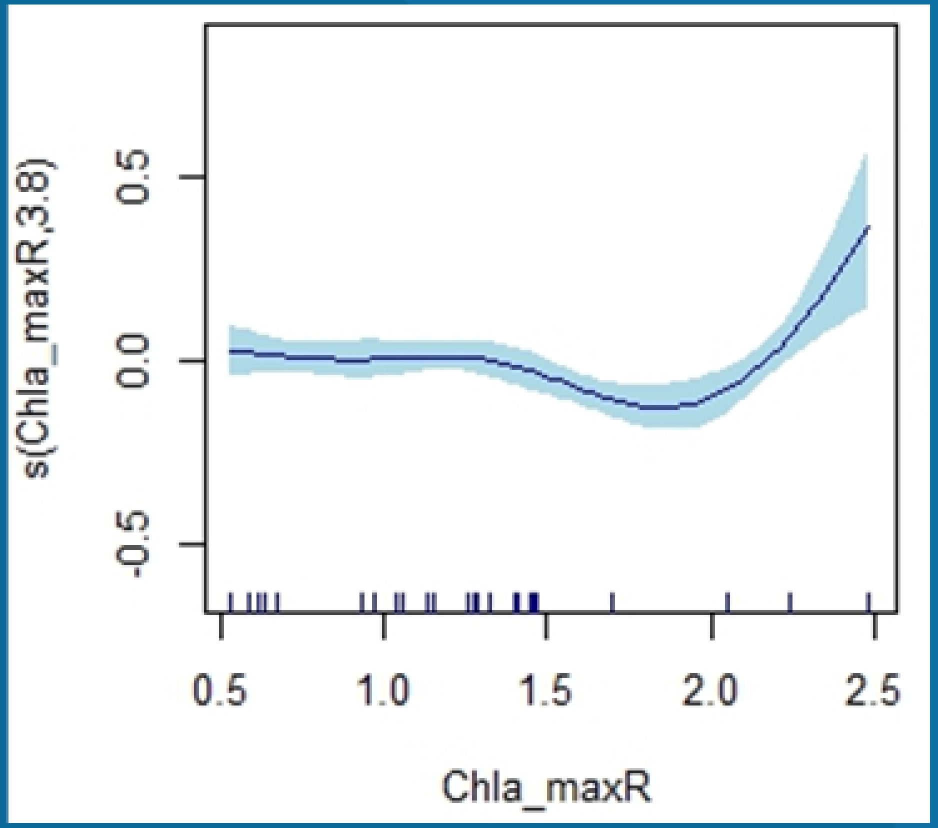
Nominal variables
Trimester/ Region

LET'S SEE SOME DATA RESULTS...

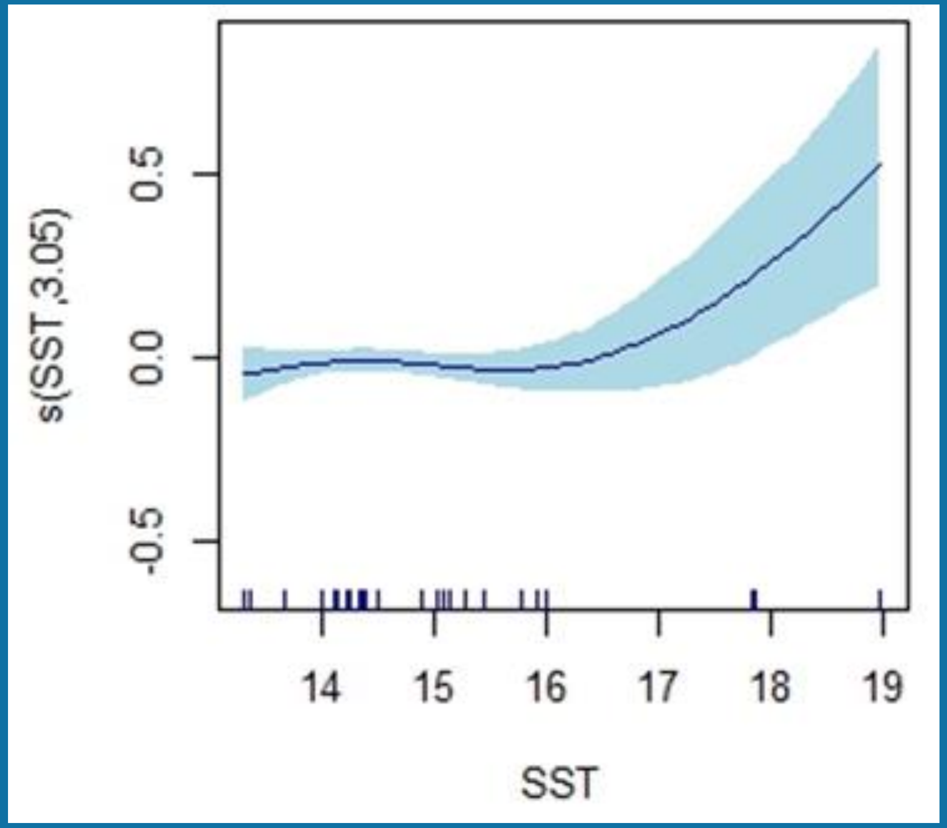
GAM’s Larvae Growth

Growth rates highly depend on the intrinsic variable **length**, and decreases with increasing length

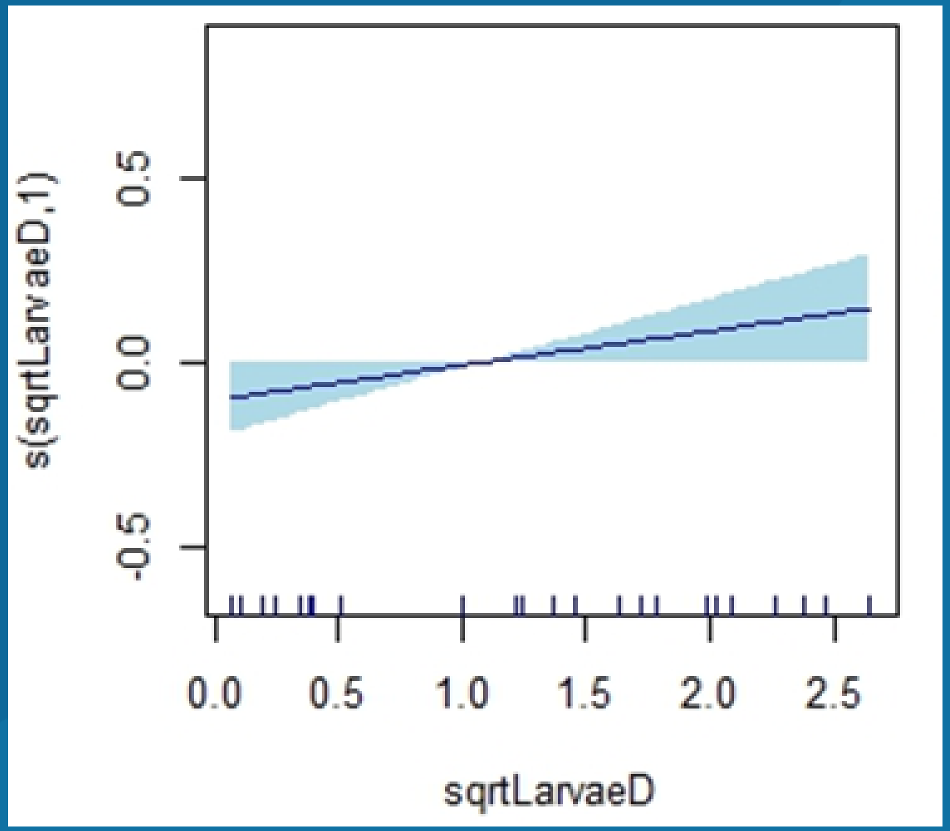
Environmental explanatory variables:



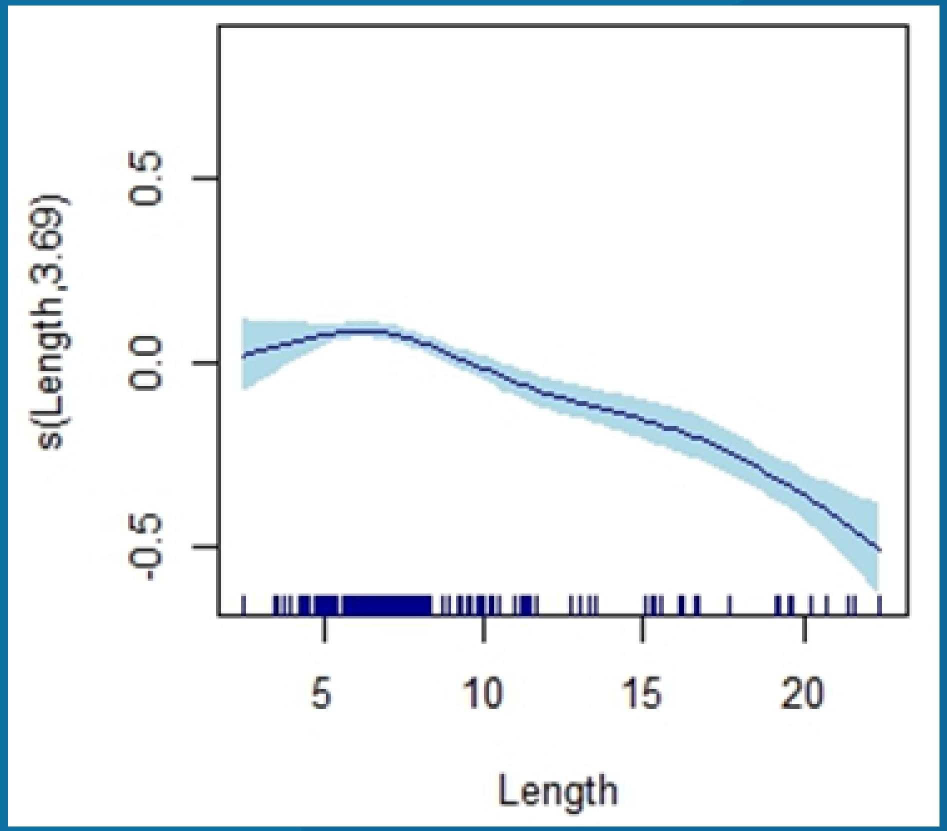
a) Chlorophyll-a



b) Sea Surface Temperature



c) Larvae Density



d) Lenght

LET'S SEE SOME DATA RESULTS...

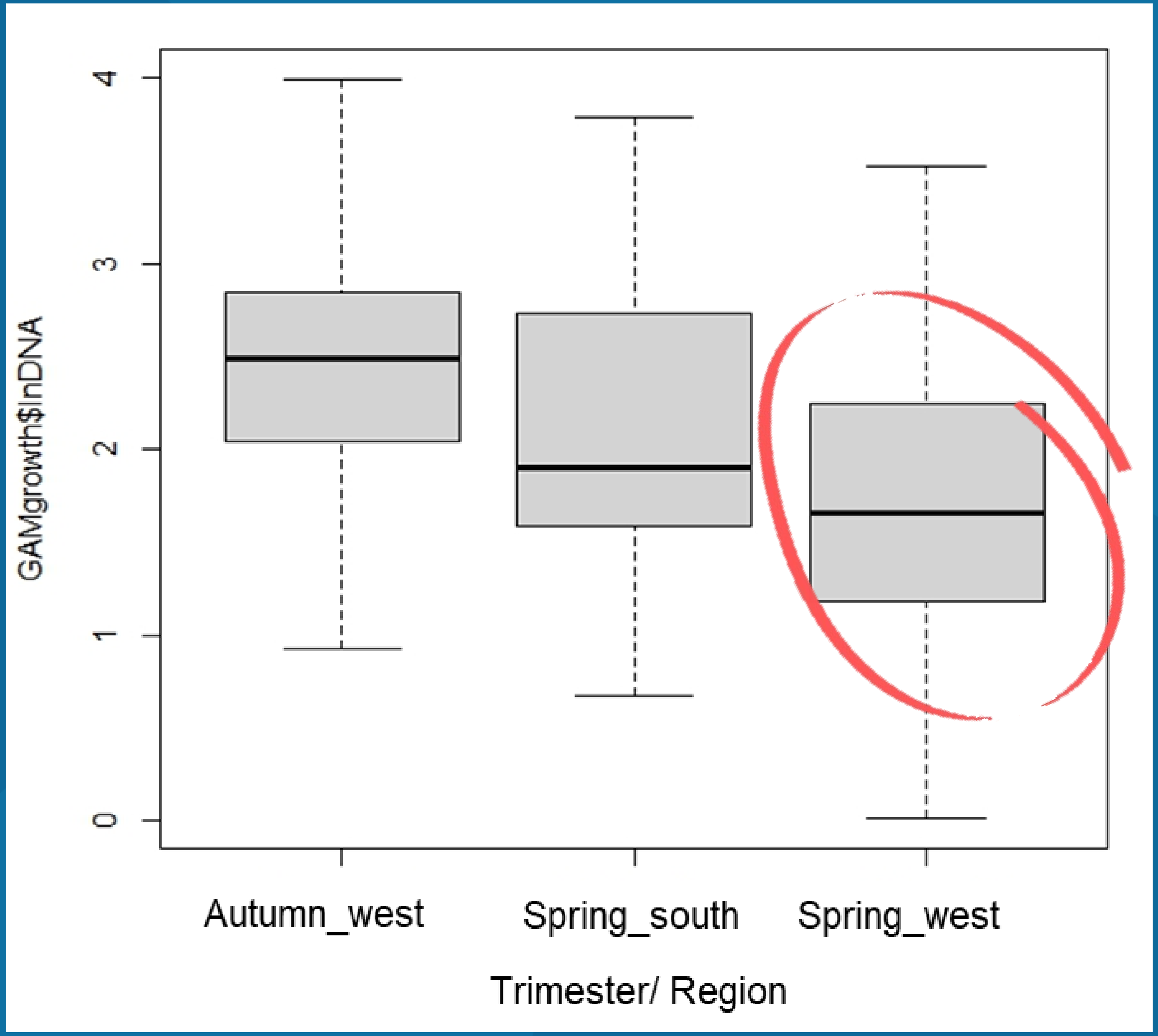
GAM’s Larvae Condition (DNA/MG)

Best fitted model: lnDNA ~ as.factor(Trimester/ Region) + s(Chla_maxR, k = 5) + s(SST, k = 5) + s(Length, k = 5)

Deviance explained = 37,5%

Larvae with lower DNA concentrations have higher somatic condition

DNA concentration in larvae was higher on the west coast in autumn and lower also on the west coast but in spring.

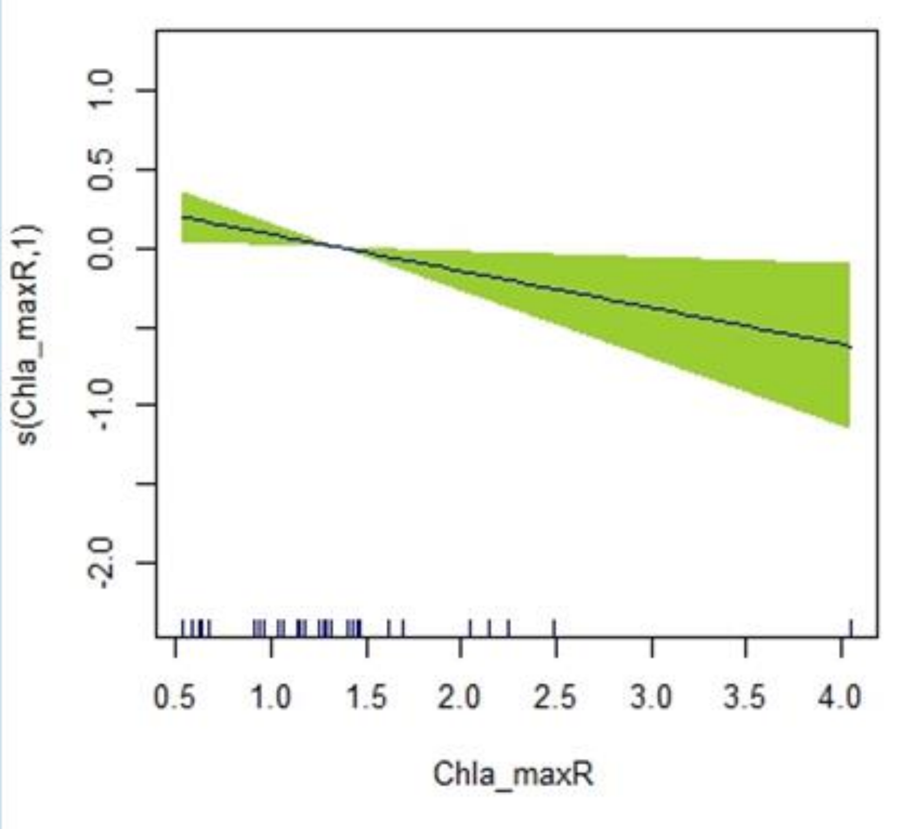


Nominal variables
Trimester/ Region

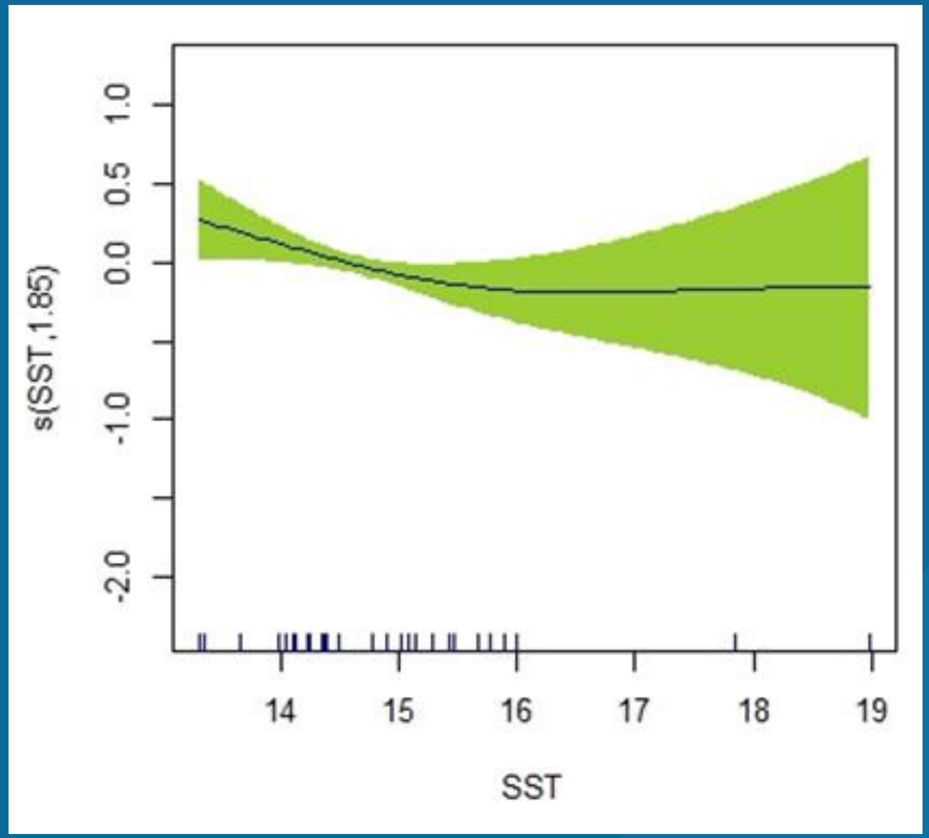
LET'S SEE SOME DATA RESULTS…

GAM's Larvae Condition (DNA/MG)

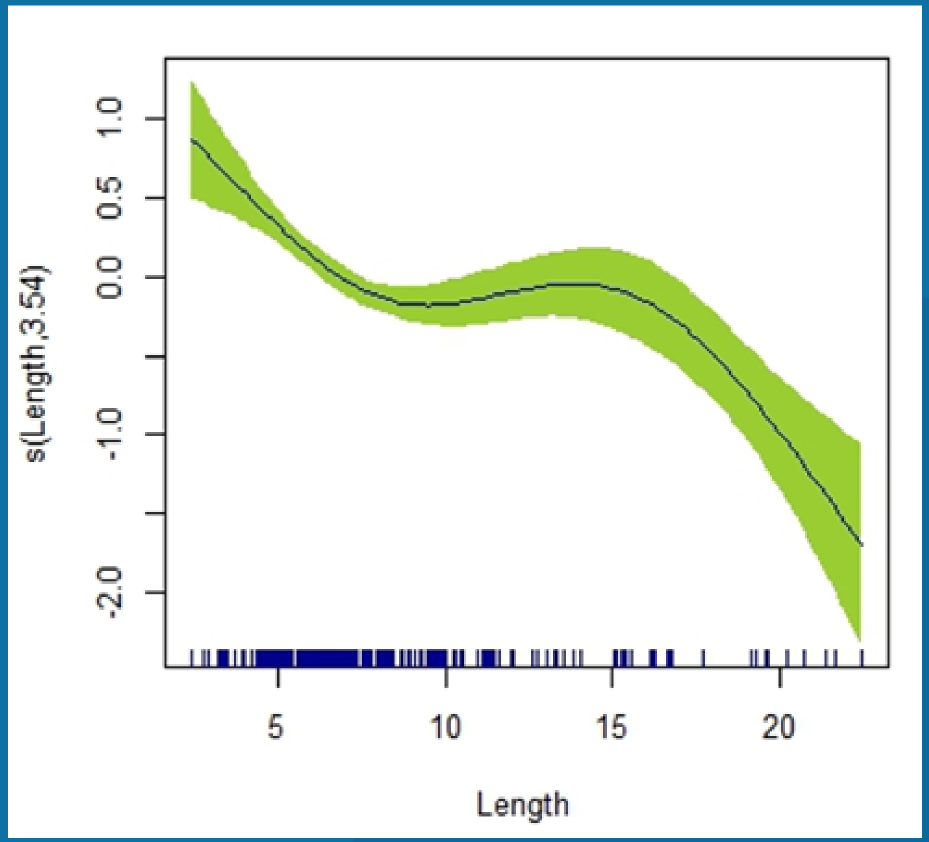
Environmental explanatory variables:



a) Clorophyll-a



b) Sea Surface Temperature (SST)



c) Length

We observed that larvae condition is highly dependent of the intrinsic variable length and less affected by the environmental variables

LET'S SEE SOME DATA RESULTS...

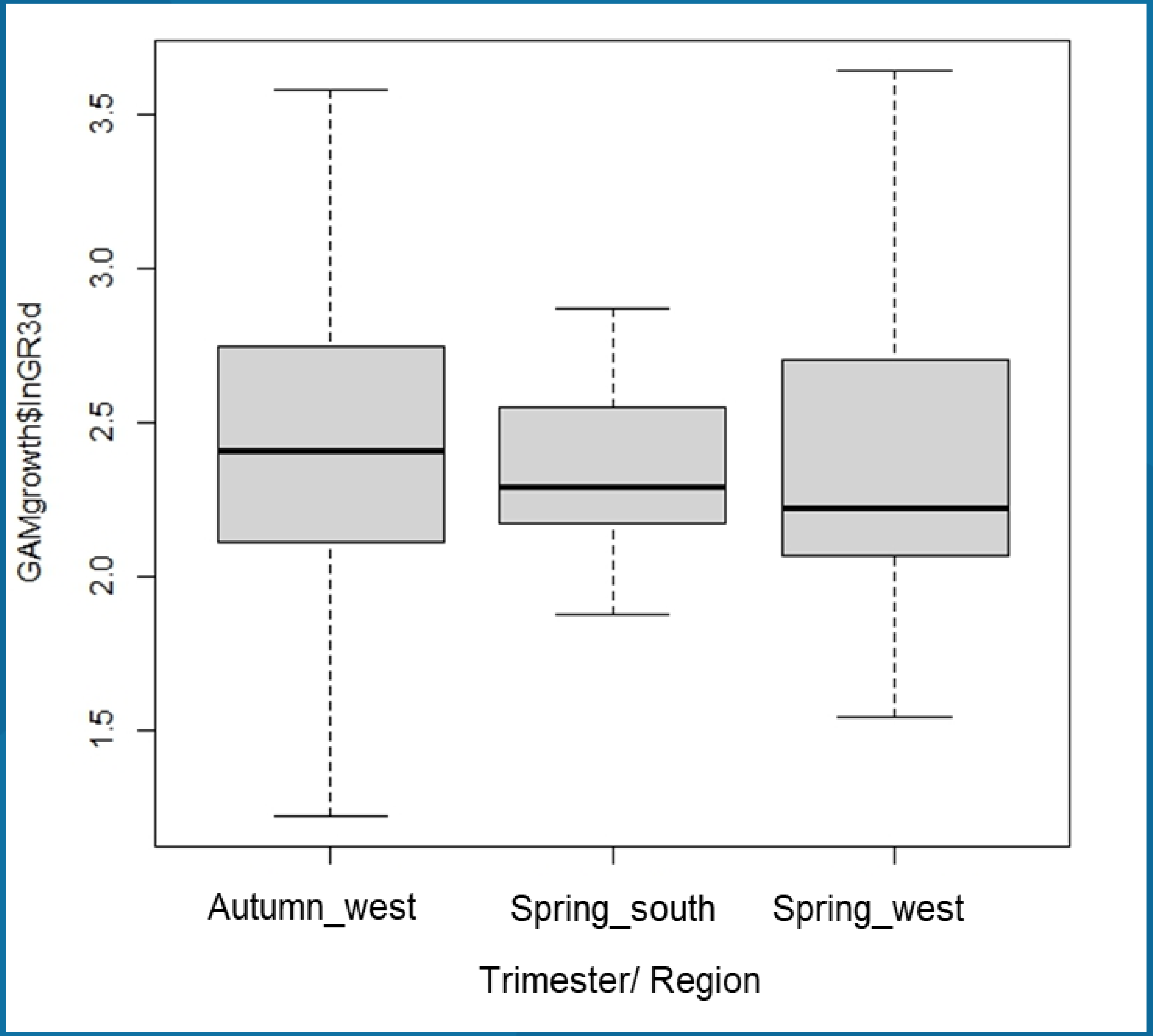
GAM's Larvae Otolith Growth

Best fitted model: lnGR3d ~ as.factor(Trimester/ Region) + s(Chla_maxR, k = 5) + s(SST, k = 5) + s(sqrtLarvaeD, k = 5) + s(Length, k = 5)

Deviance explained = 89%

No significant seasonal or regional effect was observed on otolith recent growth.

(last 3 increments width)



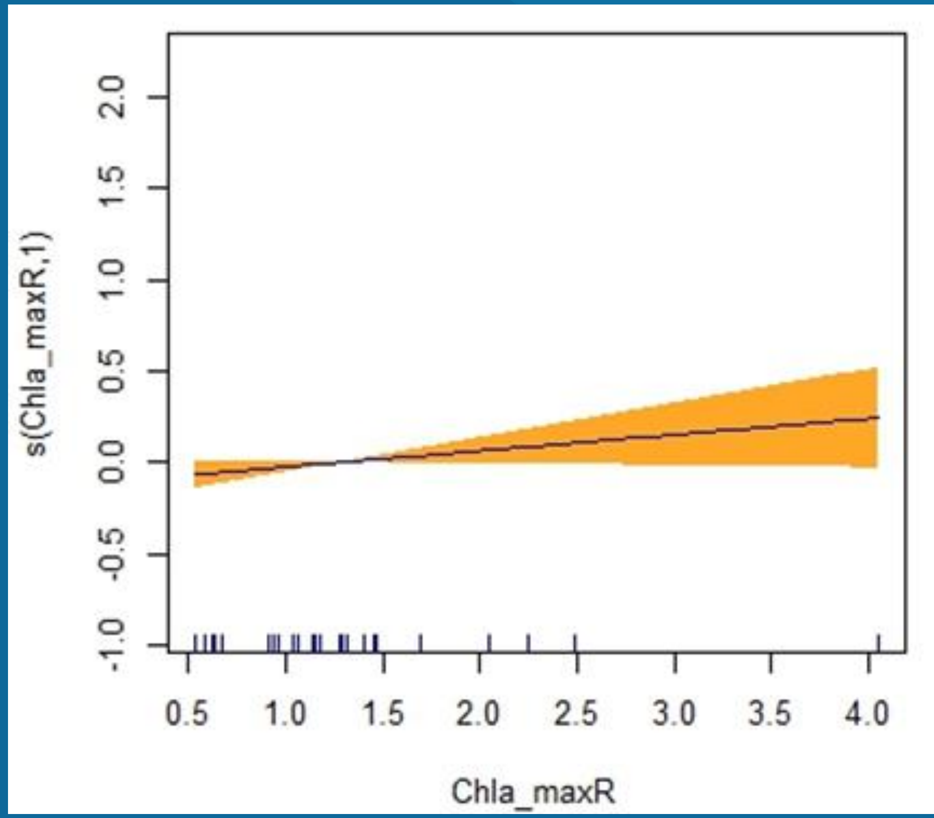
Nominal variables Trimester/ Region

LET'S SEE SOME DATA RESULTS...

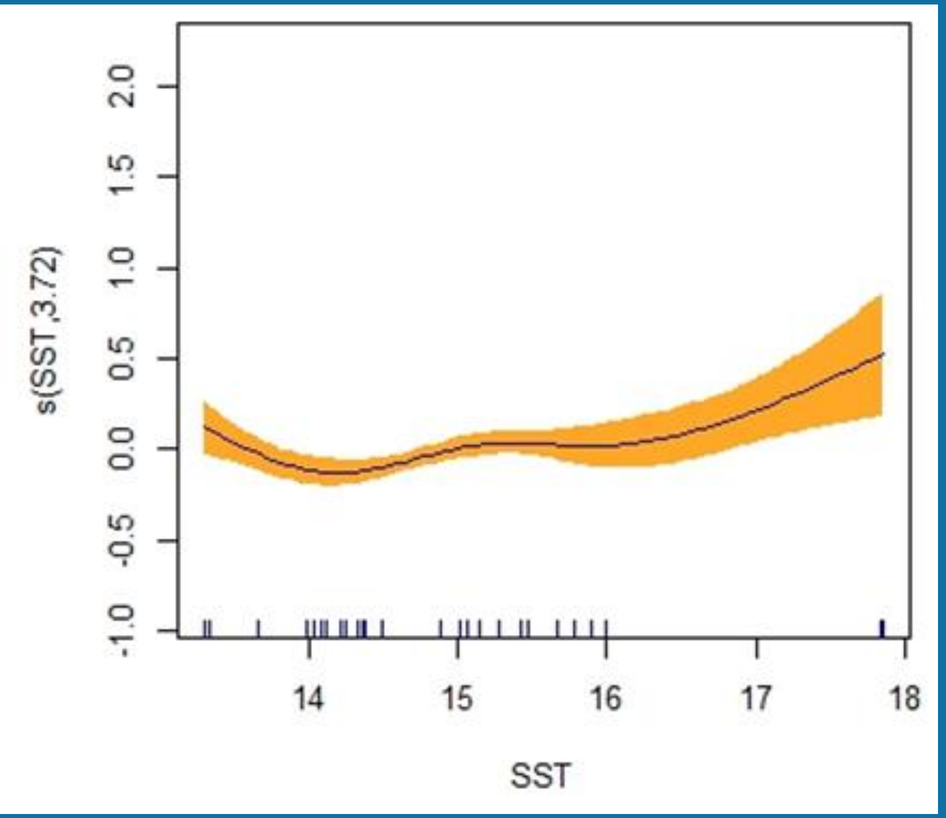
GAM's Larvae Otolith Growth

The width of the 3 external increments of larvae otoliths was found to be mainly dependent on the larvae size, meaning, they were thicker in the larger larvae.

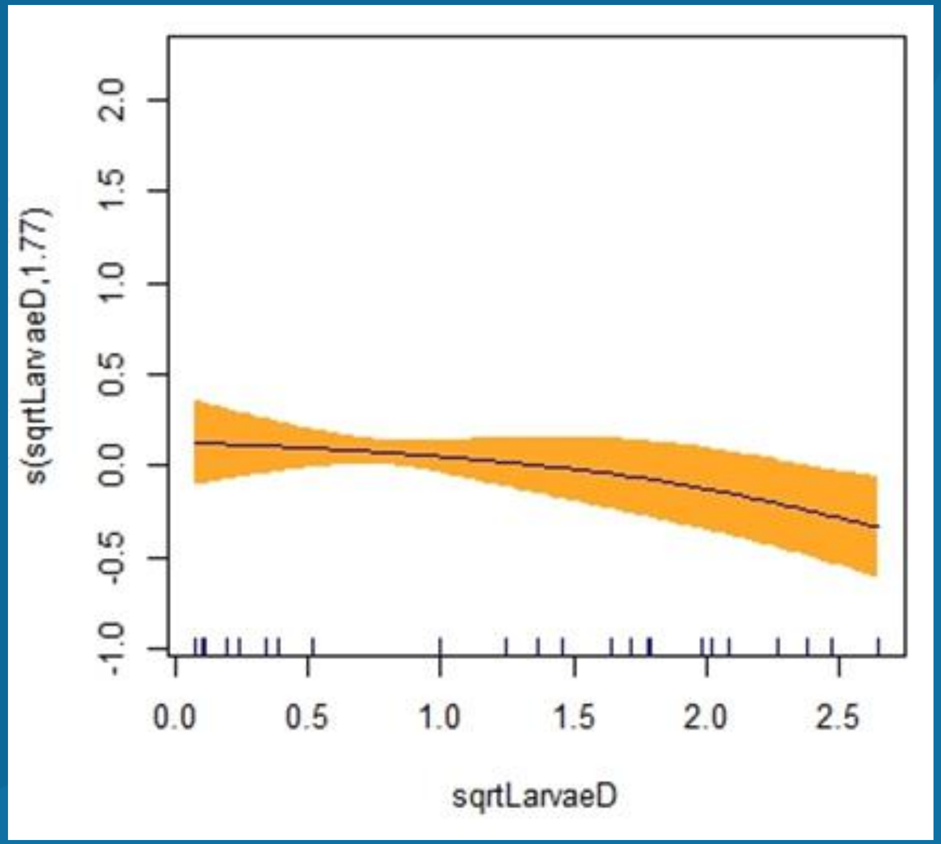
Environmental explanatory variables:



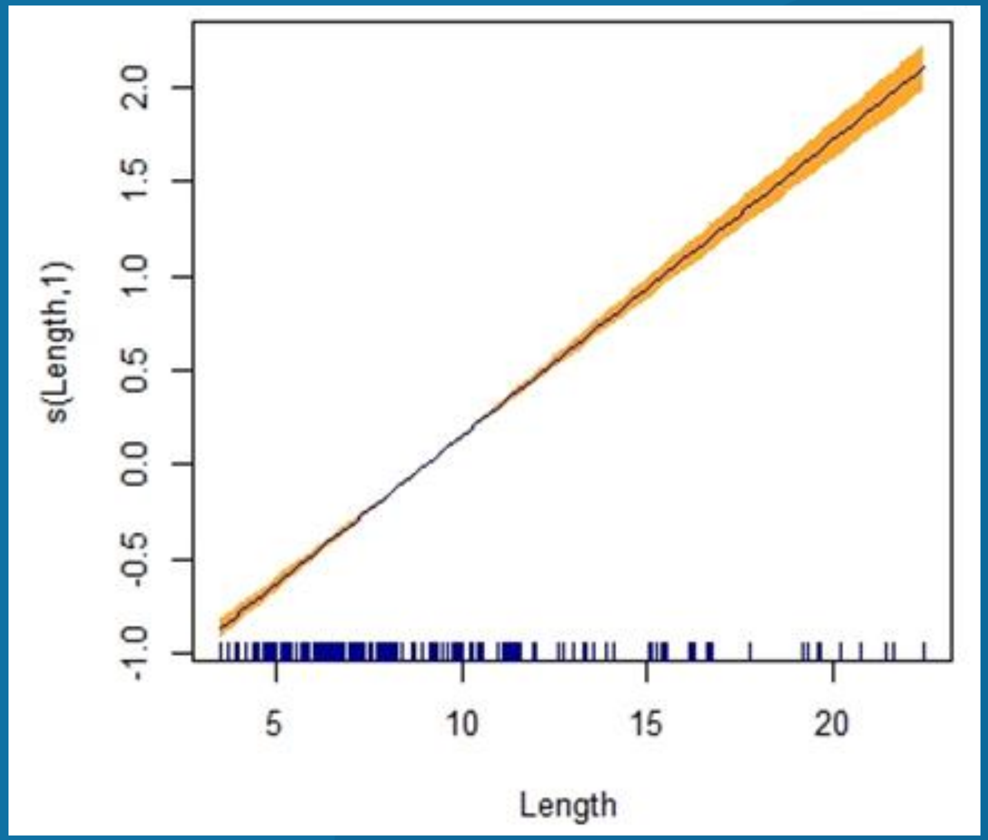
a) Chlorophyll-a



b) Sea Surface Temperature



c) Larvae Density



d) Lenght

WHAT CAN WE CONCLUDE FROM THE STUDY

- Larvae were less abundant and patchy at the beginning of spawning season, when they were mainly restricted to the more productive and colder water masses.

- In spring larval stages presented a more homogeneous distribution, with higher densities on the west coast, where ocean temperature was particularly cold that year.

- In General, higher larvae densities were found within the SST range 13 to 17ºC, which is the preferred temperature range for growth and survival of sardine as have been assessed in laboratory experiments (Garrido et al 2016).

WHAT CAN WE CONCLUDE FROM THE STUDY

Our observations in the wild confirm that temperature and food availability have a strong influence on somatic condition and growth rates, potentially acting as main drivers of recruitment success.

Sardine larvae have a preferred habitat in the cold productive waters of western Iberia.

As temperature experienced during the early life stages can have profound consequences for survival, the very low recruitment in 2018 which was proceeded by an unusually cold winter on the western Iberian shelf waters should be further investigated.

THANK YOU!

A special thanks to my supervisor Isabel Meneses

I thank to my coauthors: Ana Moreno; Susana Garrido; João Pastor

Also thanks to the research team of survey JUVESAR and PELAGO

This work was done as part of my master's degree

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