Drivers of Dynamics of Small Pelagic Fish Resources
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Comparative early life trophodynamics and larval growth of Alborán Sea sardine environmentally distinct larval habitats (Bays of Málaga and Almería) (Sardina pilchardus) (SW Mediterranean)

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CONSEJERÍA DE ECONOMÍA Y CONOCIMIENTO
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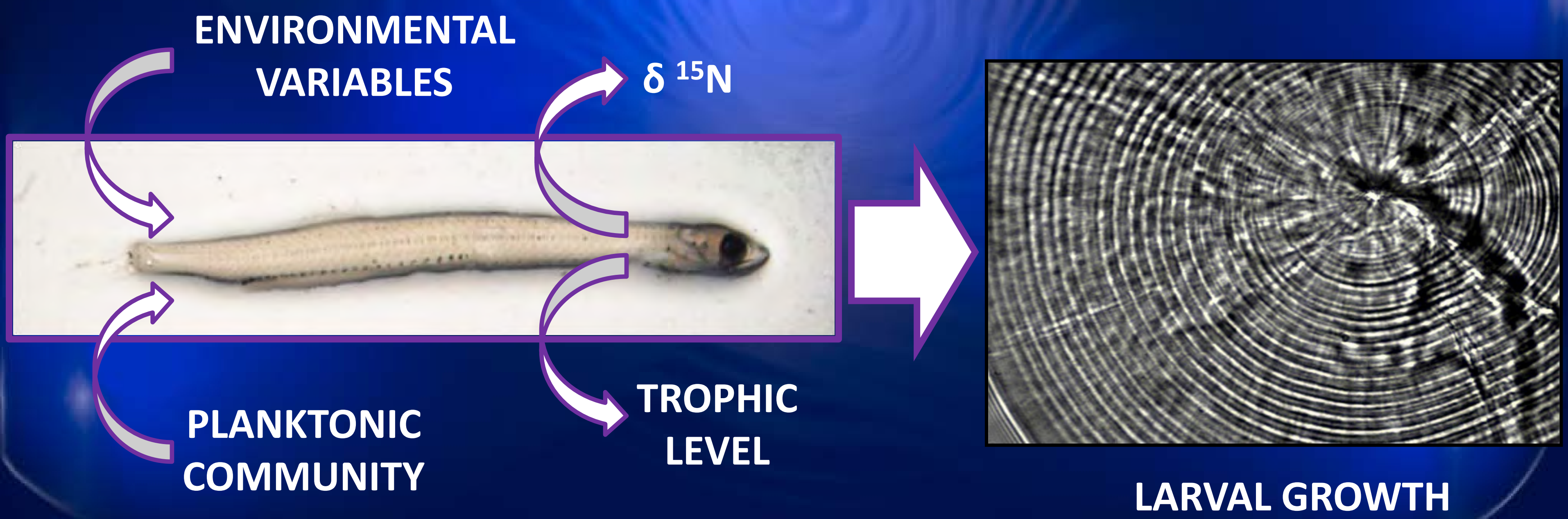
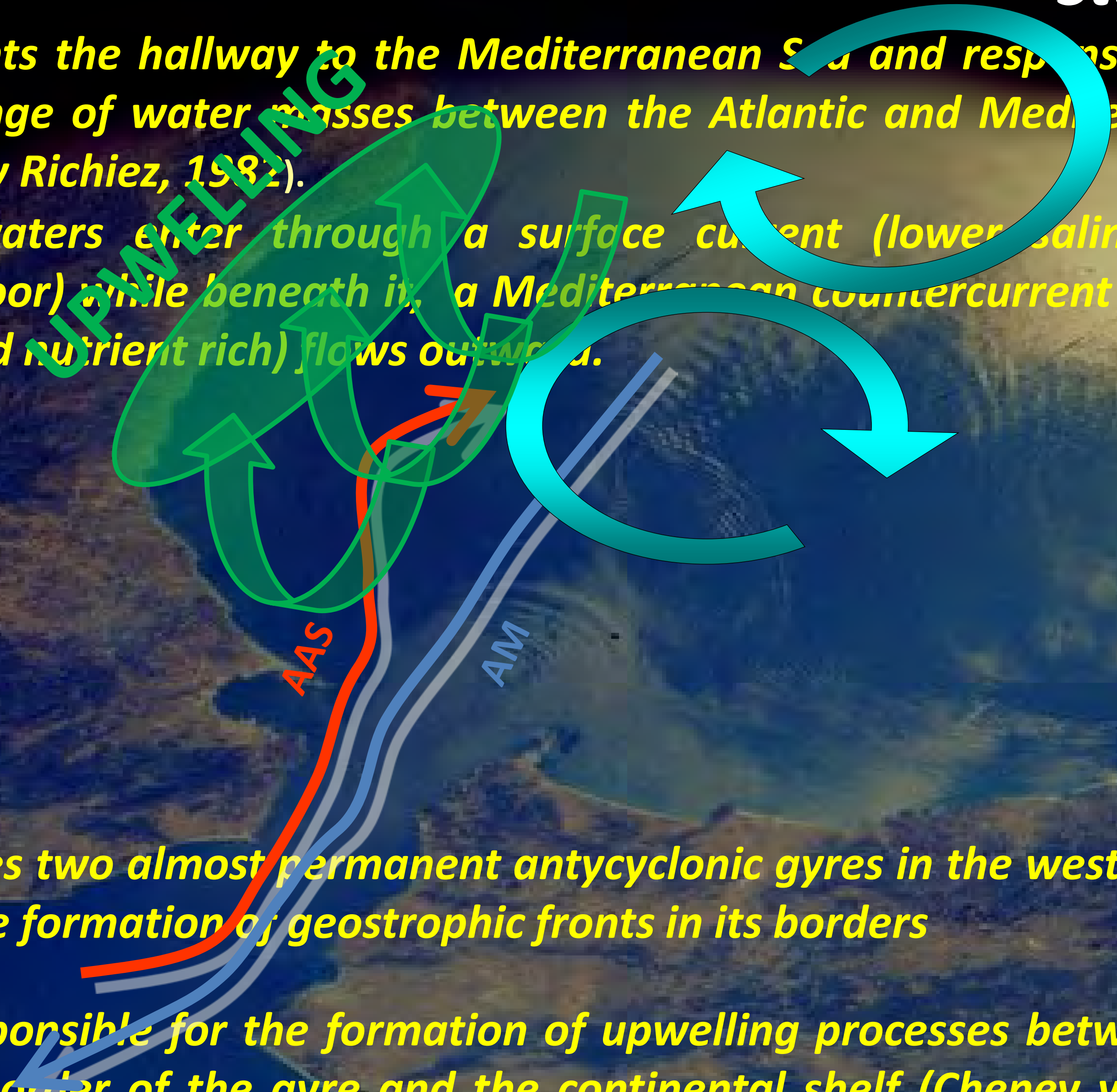
Objetive

The main objective of this study is to determine the influence of environmental and isotopic trophic variables on growth of postlarval sardines at different sites and different seasonal periods during the sardine spawning season



Study area

- *It represents the hallway to the Mediterranean Sea and responsible for the exchange of water masses between the Atlantic and Mediterranean (Lacombe y Richiez, 1982).*
- *Atlantic waters enter through a surface current (lower salinity and nutrient poor) while beneath it, a Mediterranean countercurrent (higher salinity and nutrient rich) flows outward.*



- *It generates two almost permanent antycyclonic gyres in the western part causing the formation of geostrophic fronts in its borders*
- *This is responsible for the formation of upwelling processes between the northern border of the gyre and the continental shelf (Cheney y Doblar, 1982).*

Study area

Based on the two main small pelagic nursery sites, being the Bay of Málaga most important in relation to sardine recruitment grounds

These nursery sites have very distinctive environmental features:

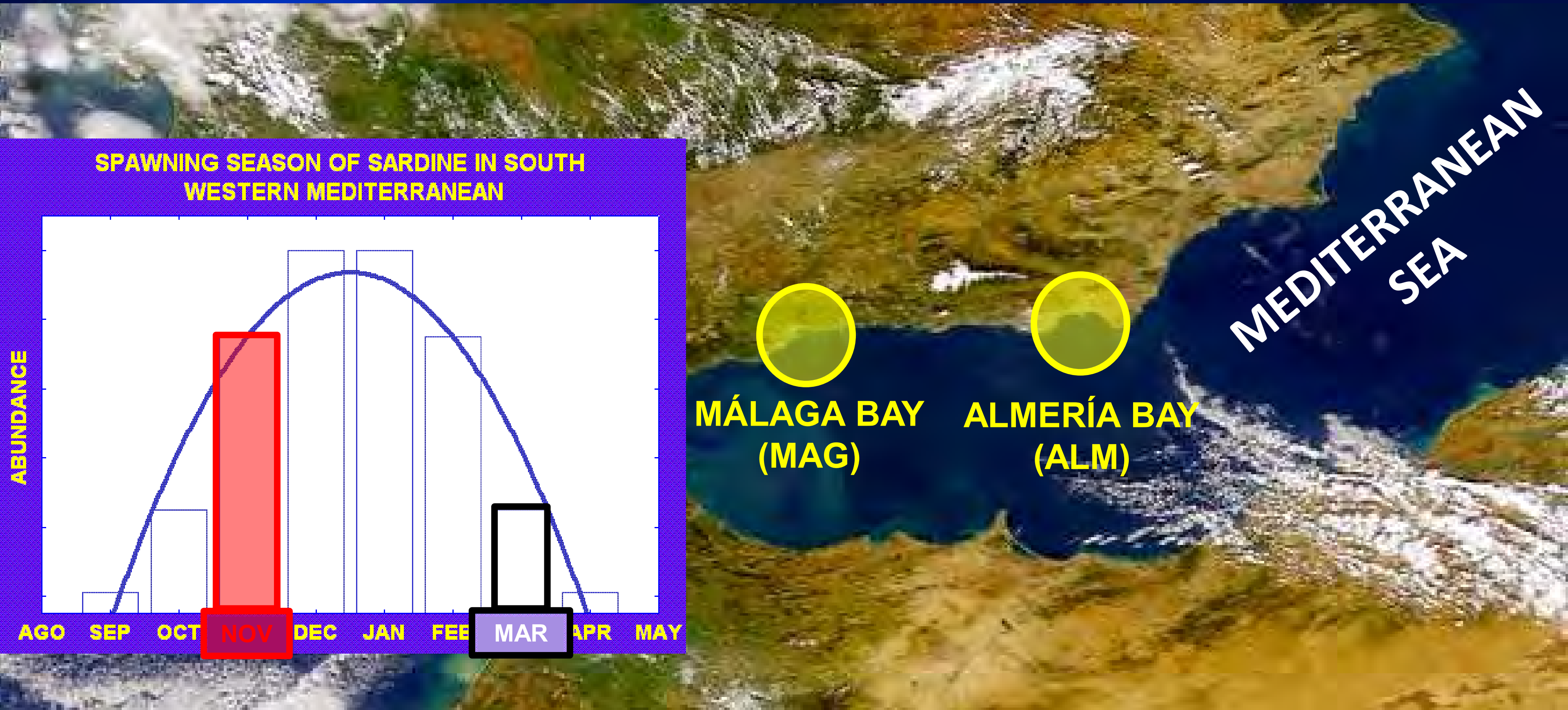
MÁLAGA BAY

Influence of Atlantic surface current inducing upwelling and enrichment of waters

ALMERÍA BAY

Mediterranean waters characterized by their lower productivity

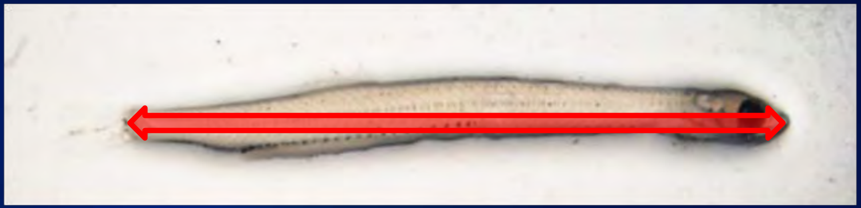
Samples



SURVEY	BAY	Size Classes	SL Mean	SL Std. Err.	N
TF 1111	MAG	10-21	16.42	0.33	84
	ALM	10-21	16.03	0.33	85
TF 0312	MAG	11-19	15.95	0.29	60
	ALM	11-19	15.26	0.27	66

LARVAE

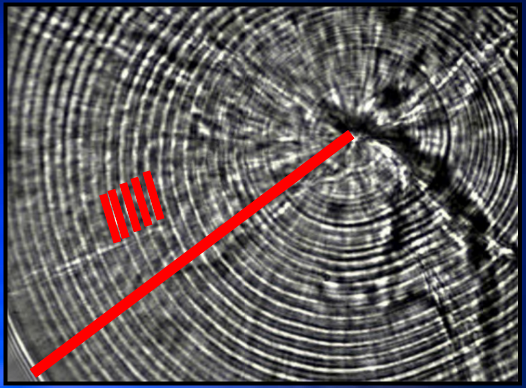
Variables



Somatic variables

Standard Length (mm)

Dry Weight (mg)



Otolith biometry

Nº increments

Radius (microns)

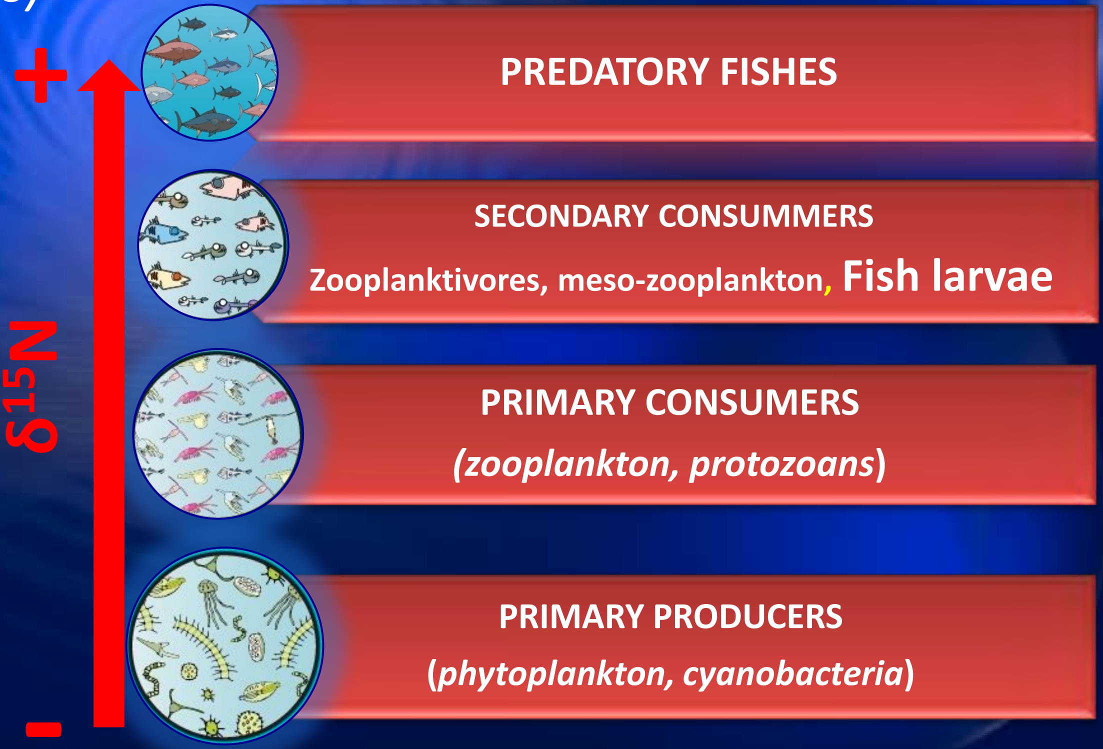
Increment Width (microns)

Trophic variables

δ^{15}N larvae (‰)

Trophic Level

Stable nitrogen isotopes become enriched at successive trophic levels, as more of the light isotope (^{14}N) is secreted than the heavy isotope, leaving the animal enriched in ^{15}N relative to Its food source.



Environmental variables

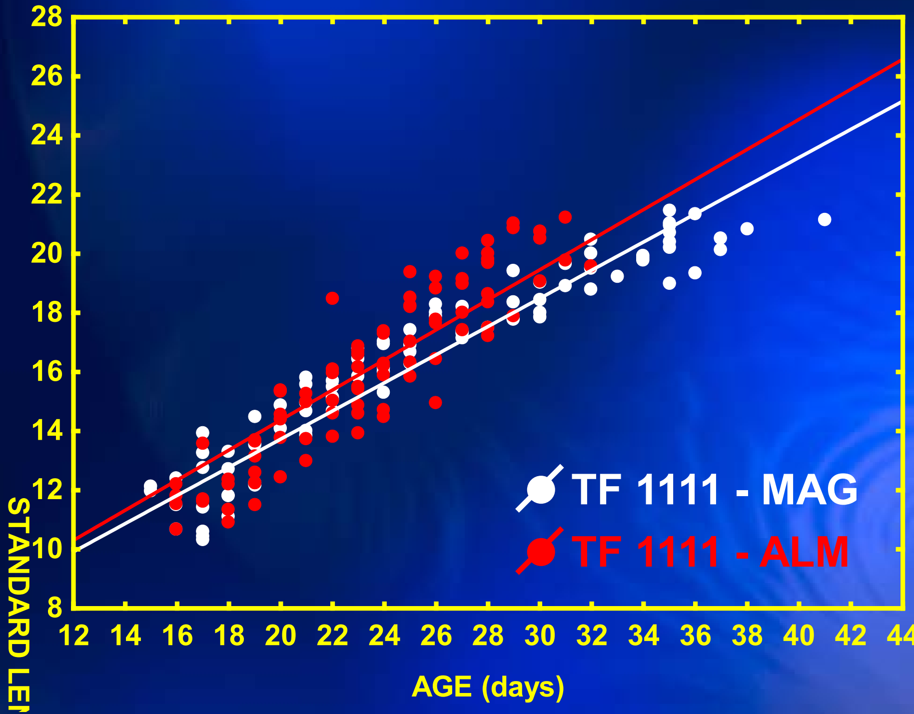
Temperature (ºC)
Salinity (‰)
Fluorescence (RFU)
Chloropyll (µg/L)

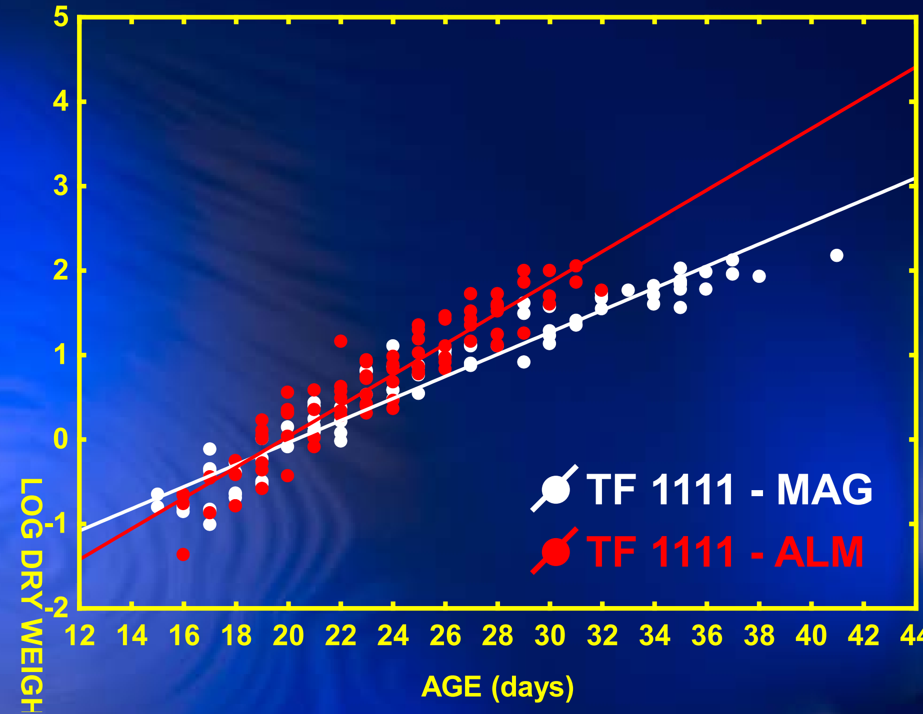
Mesozooplankton (200-500 microns)

Biomass (mgDW/m^3)
δ^{15}N *mesozooplankton (‰)*
Cladocera (ind/m^3)
Copepods (ind/m^3)
Nauplius copepods (ind/m^3)
Appendicularia (ind/m^3)

Bode et al. 2004
Morote et al. 2010
Costalago et al. 2012
Borme et al. 2013

TF 1111 – *Growth patterns of somatic variables*





ANCOVA SL vs AGE

F (1, 166) = 11.93; p < 0.01

ALM > MAG

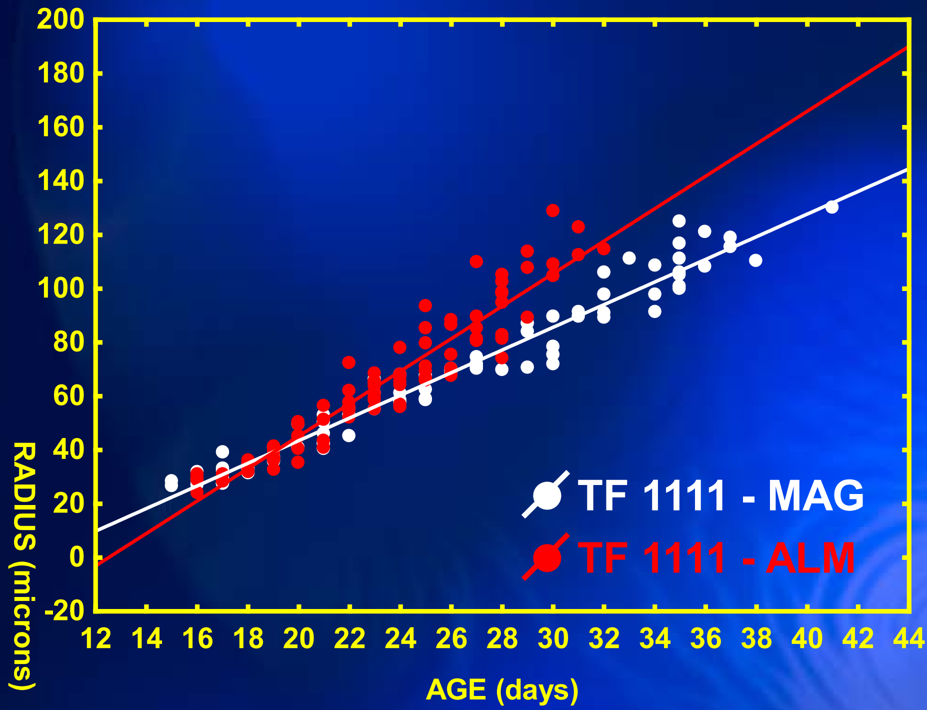
ANCOVA LOGDW vs AGE

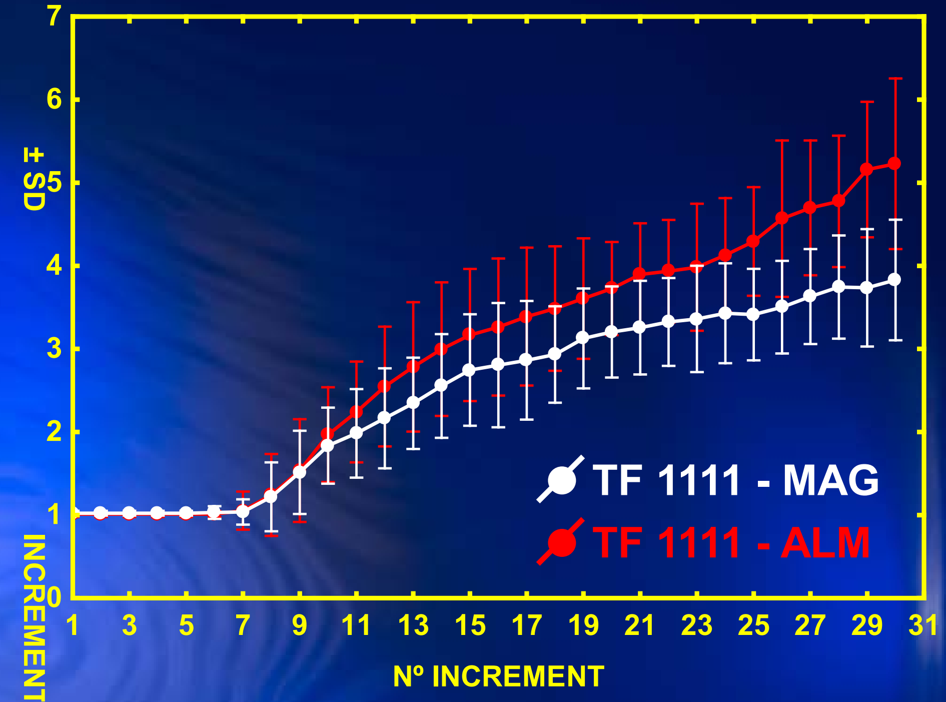
F (1, 166) = 38.36; p < 0.01

ALM > MAG

Larvae from ALM showed faster growth (SL & DW) than MAG

TF 1111 – *Otolith biometry*





ANCOVA RADIUS vs AGE

$F(1, 166) = 47.13; p < 0.01$

ALM > MAG

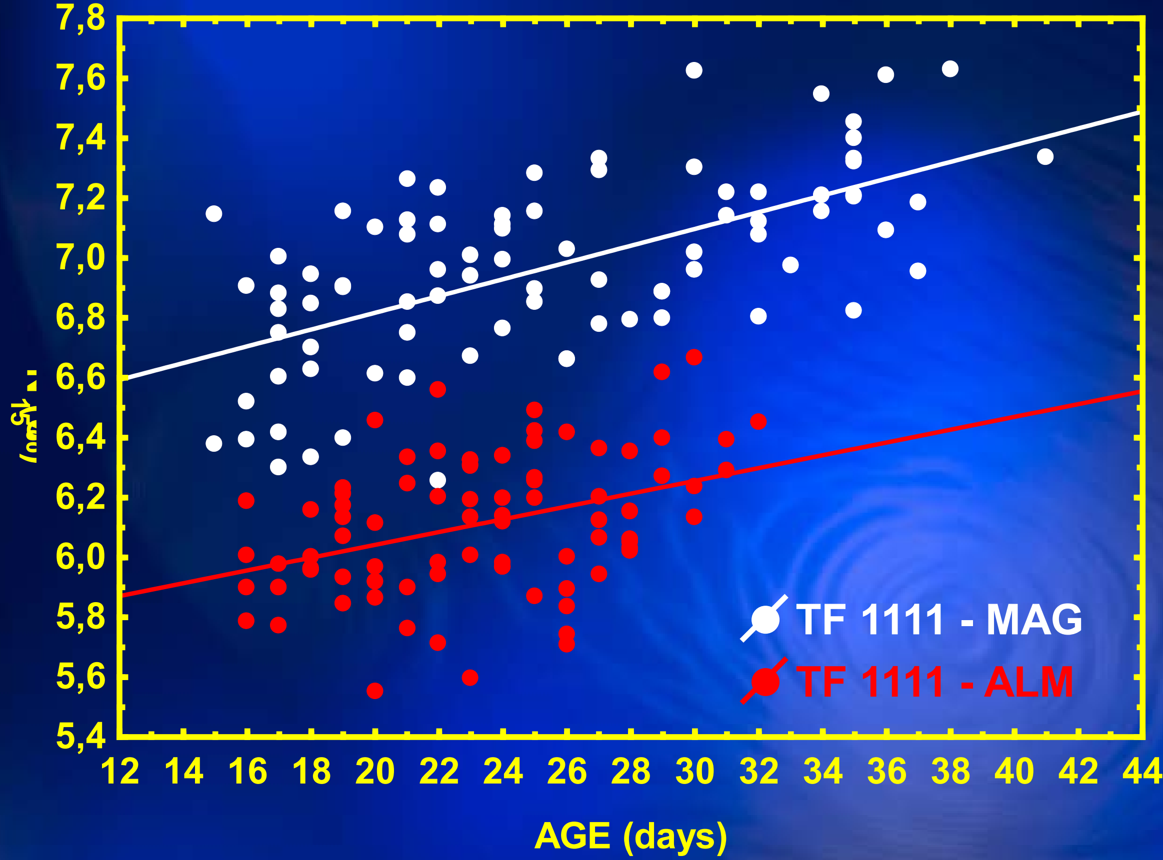
ANCOVA INC-MED vs AGE

$F(1, 166) = 40.53; p < 0.01$

ALM > MAG

Higher growth potential is reflected in the otoliths. Larvae from ALM showed larger otoliths with wider increments in comparison with MAG population.

TF 1111 – *Trophic variables*



ANCOVA $\delta^{15}N$ vs AGE

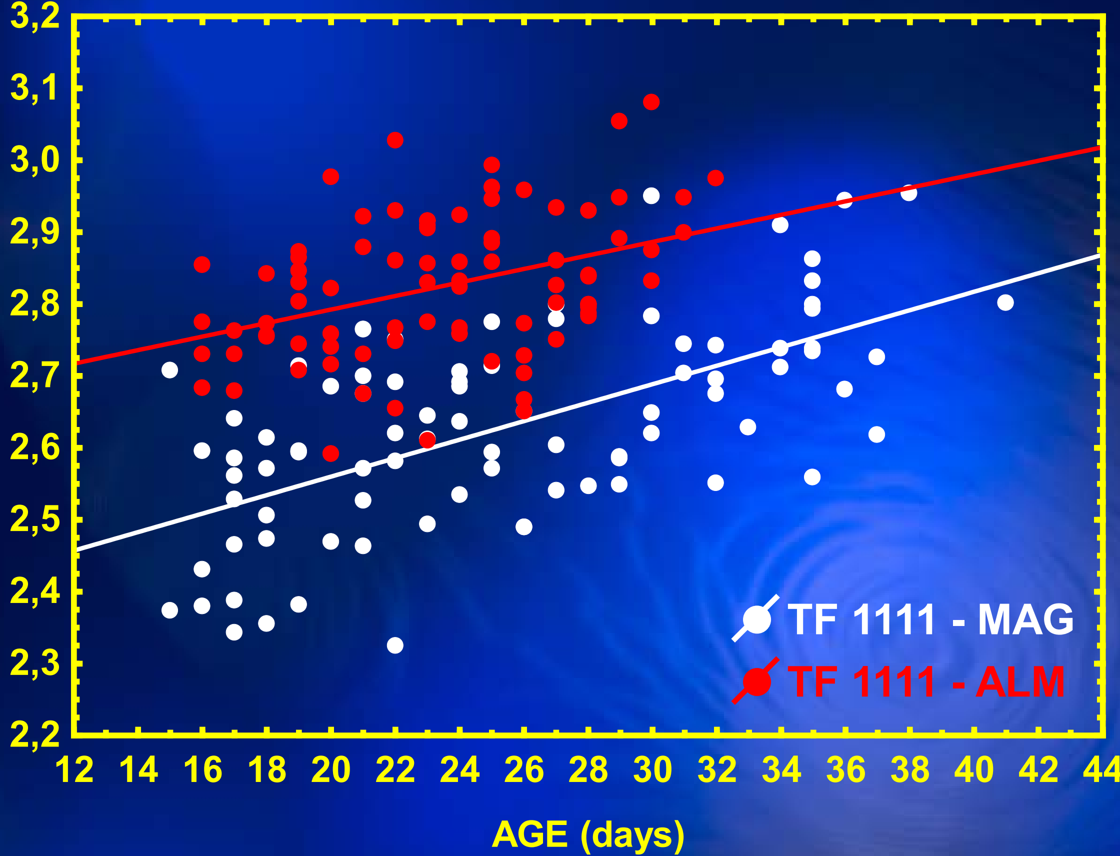
$F(1, 166) = 501.05$; $p < 0.01$

MAG > ALM

Larvae from MAG present higher values of $\delta^{15}N$

$\delta^{15}N$ increases significanly with age in both populations, implying diet changes with larval growth

TF 1111 – *Trophic variables*



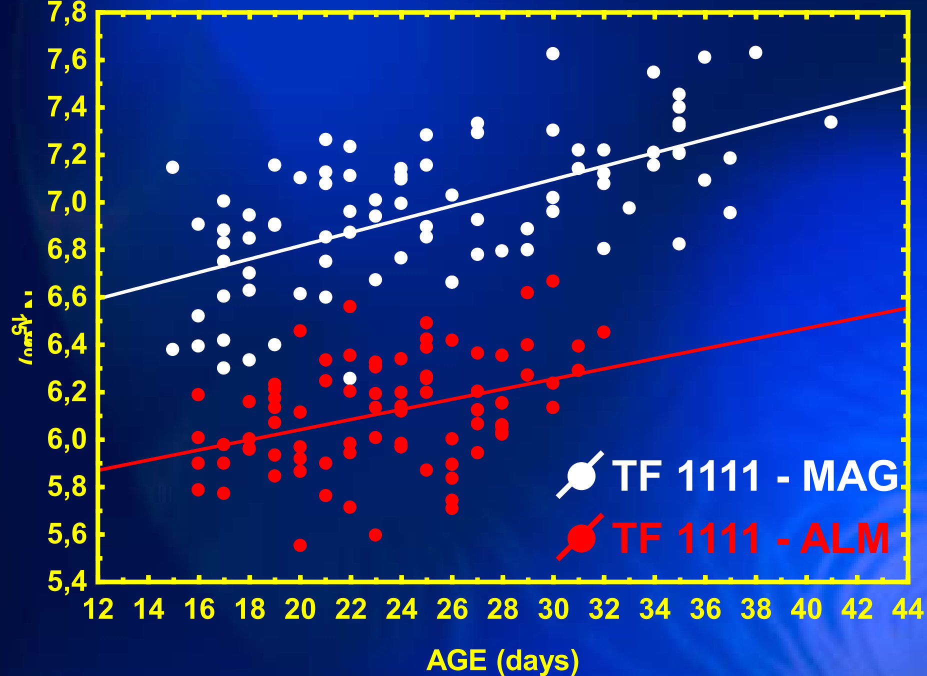
ANCOVA TL vs AGE

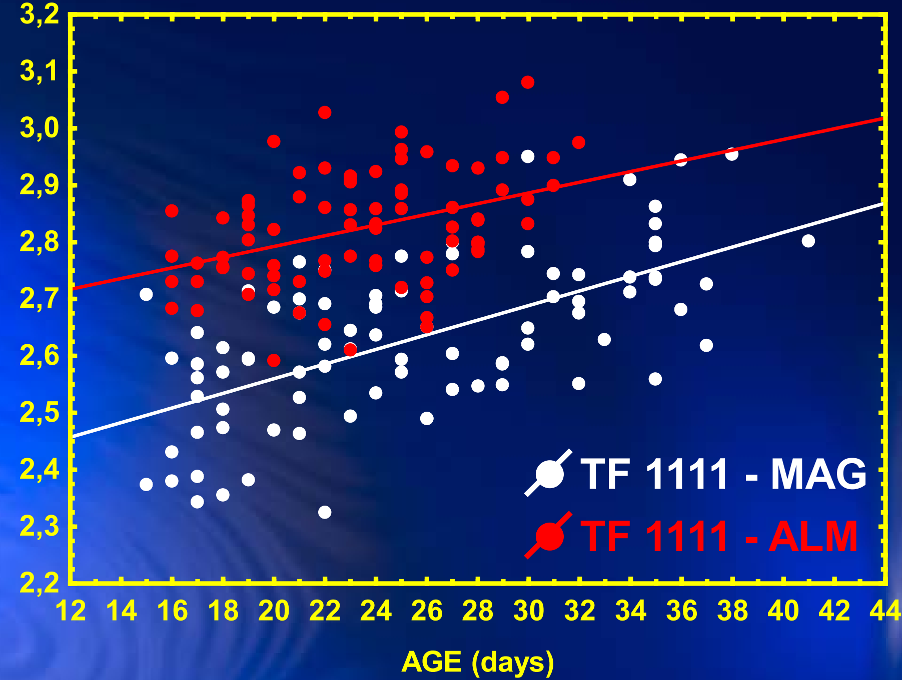
F (1, 166) = 185.87; p < 0.01

ALM > MAG

Larvae from ALM present higher trophic levels, which is interpreted as having a more selective feeding behaviour in comparison with larvae from MAG

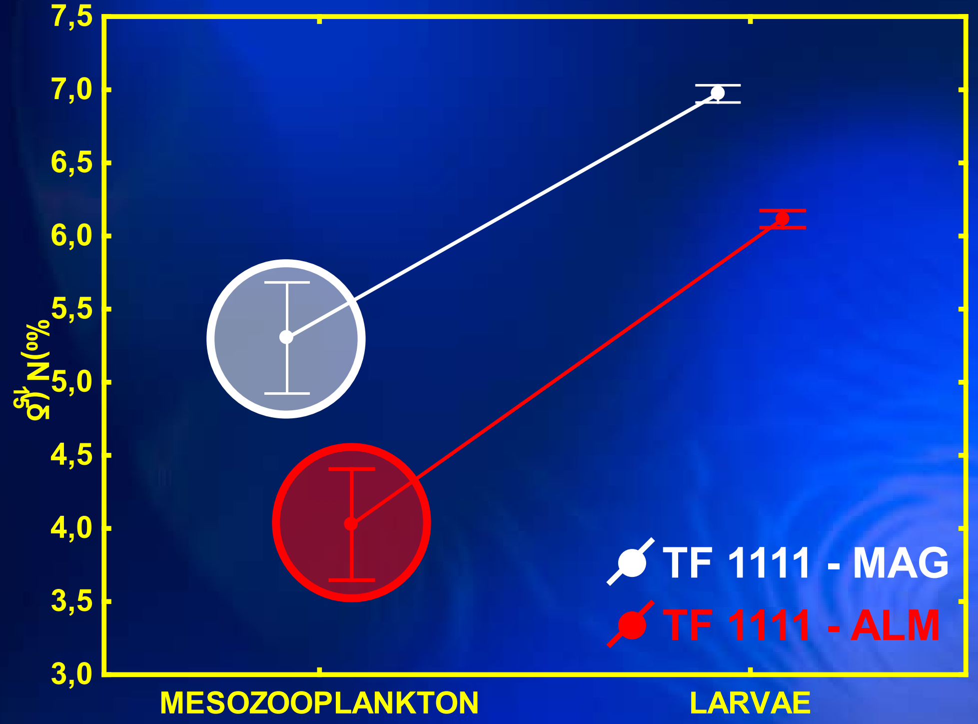
TF 1111 – *Trophic variables*





NOW WE MAY ASK OURSELVES……, WHY DO LARVAE WITH LOWER $\delta^{15}N$ VALUES HAVE HIGHER TROPHIC LEVELS?

TF 1111 – *Trophic variables and the planktonic community*



Different isotopic signatures of the mesozooplankton fraction is related to the differences of each planktonic community that ultimately determines δ^{15}N values of larvae

Higher concentration of Appendicularia in MAG would indicate a recycled N utilization in the system increasing the δ^{15}N values of the mesozooplankton

Mesozooplankton	**MAG**	**ALM**
δ^{15}N (‰)	5.30	4.03
Biomass (mg/m^3)	25.08	14.00
Cladocera (ind/m^3)	1817.55	34.06
Copepods (ind/m^3)	6250.81	2108.44
Nauplius Copepods (ind/m^3)	188.33	1.57
Appendicularia (ind/m^3)	838.52	186.73

ANOVA

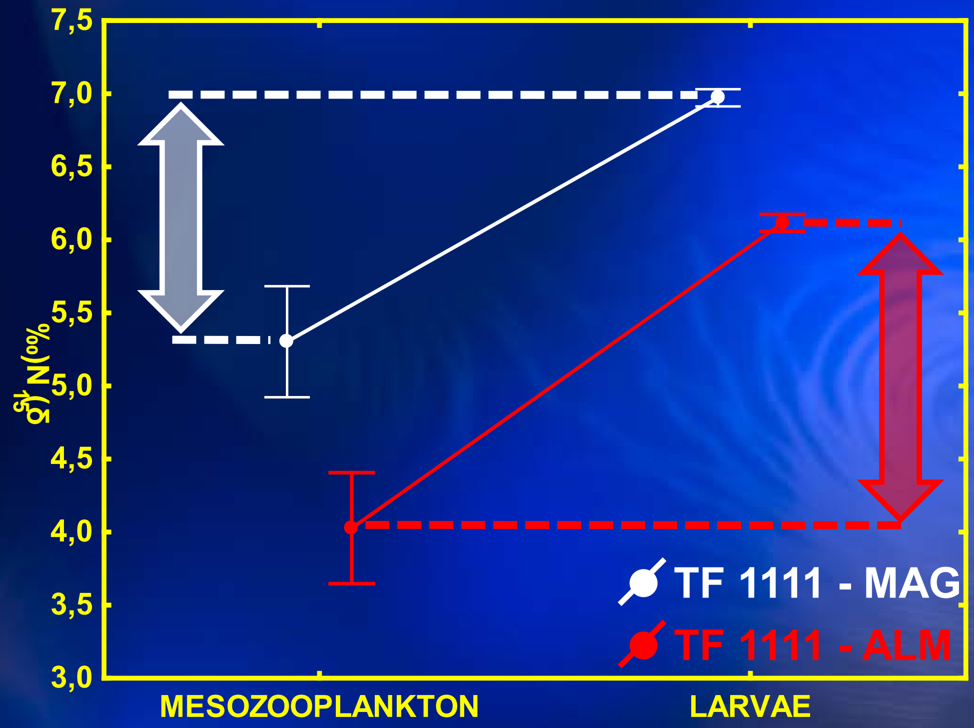
$p < 0.05$

$p < 0.1$

TF 1111 – *Trophic level*

$$TL_{consumer}=TL_{basal}+(\delta^{15}N_{consumer}-\delta^{15}N_{prey})/\Delta\delta^{15}N$$

ENRICHMENT



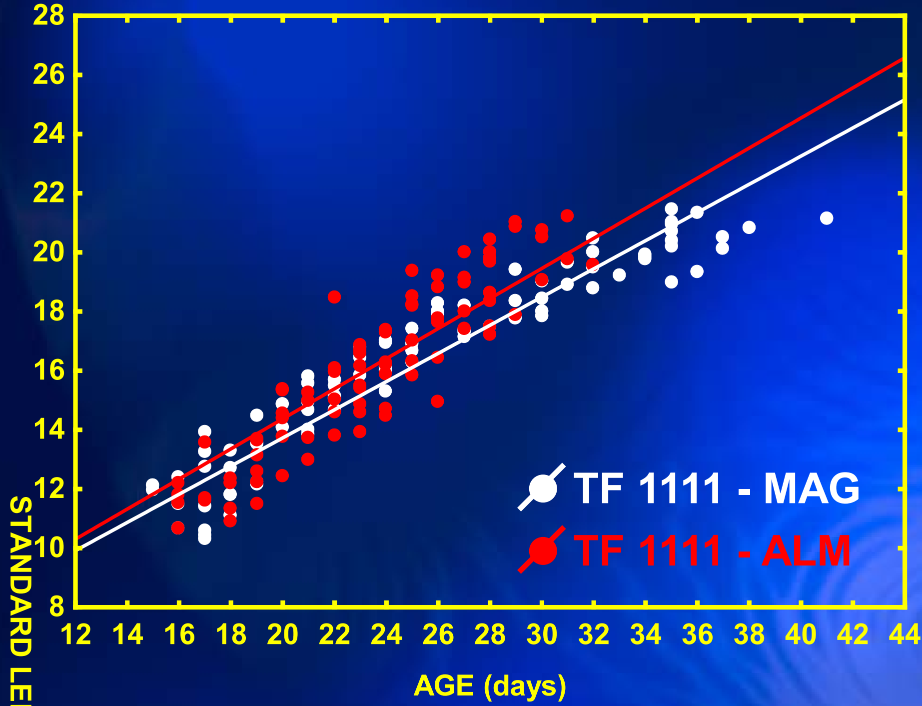
MAG 1.65±0.02

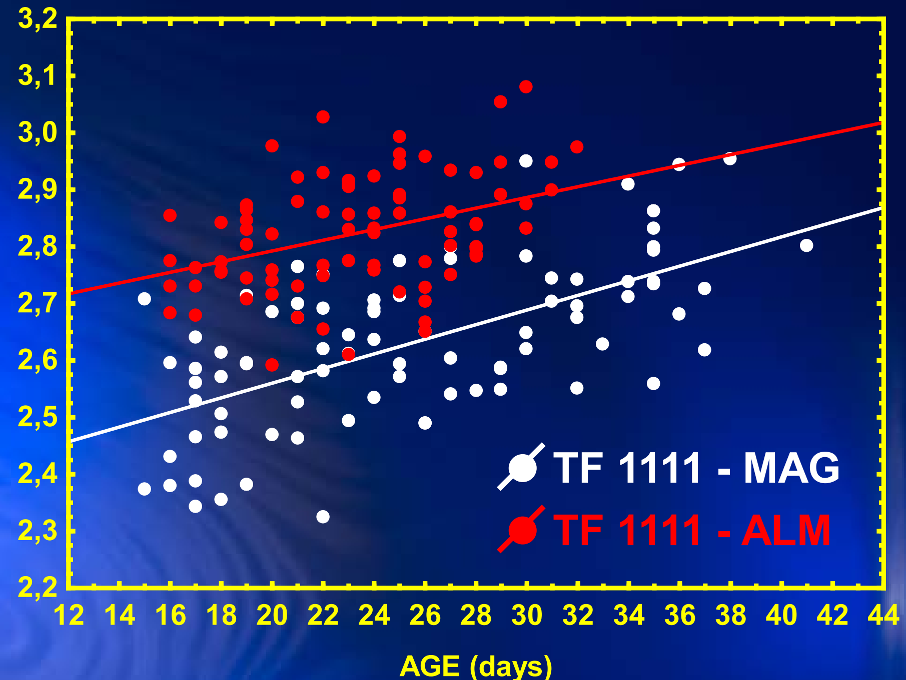
ALM 2.11±0.02

TROPHIC LEVEL

ALM > MAG

TF 1111 – *Growth pattern and Trophic variables*





ANCOVA SL vs AGE

F (1, 166) = 11.93; p < 0.01

ALM > MAG

ANCOVA TL vs AGE

F (1, 166) = 185.87; p < 0.01

ALM > MAG

Larvae with higher Trophic Levels showed faster growth

ENVIRONMENTAL VARIABLES INFLUENCE?

TF 1111 – *Environmental variables*

Environmental	MAG	ALM
Temperature	16.43	18.71
Salinity	36.55	37.82
Fluorescence	0.41	0.35
Chlorophyll	0.65	0.97

+2.28 ºC

IS FASTER GROWTH DUE TO DIFFERENCE IN TEMPERATURE BETWEEN AREAS MORE THAN IN FEEDING BEHAVIOUR?

ANOVA
$p < 0.05$
$p < 0.1$

TF 0312 – *Environmental variables*

Environmental	MAG	ALM
Temperature	13.47	13.99
Salinity	38.24	38.23
Fluorescence	0.82	0.57
Chlorophyll	1.66	1.82

+0.52 ºC

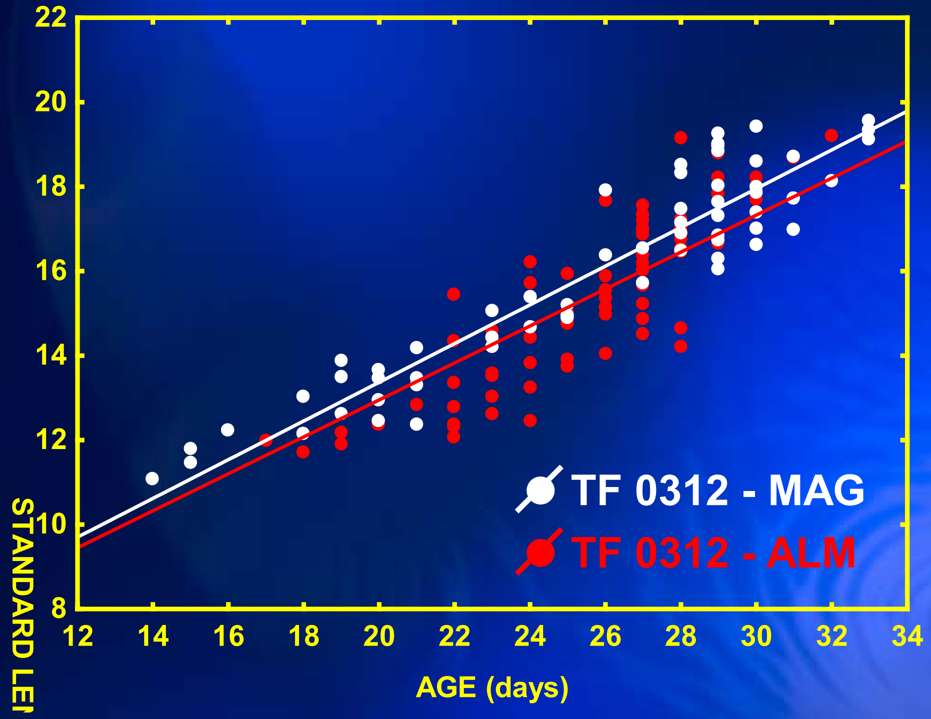
SURVEY	BAY	Size Classes	SL Mean	SL Std. Err.	N
TF 0312	MAG	11-19	15.95	0.29	60
	ALM	11-19	15.26	0.27	66

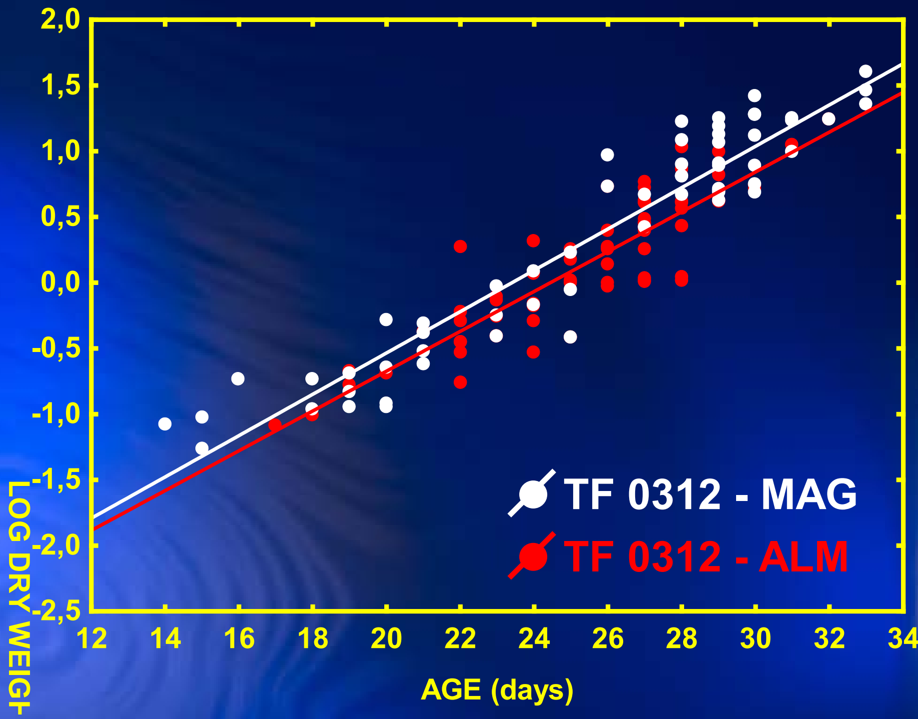
ANOVA

$p < 0.05$

$p < 0.1$

TF 0312 – *Growth patterns of somatic variables*





ANCOVA SL vs AGE

$F(1, 123) = 11.22; p < 0.01$

MAG > ALM

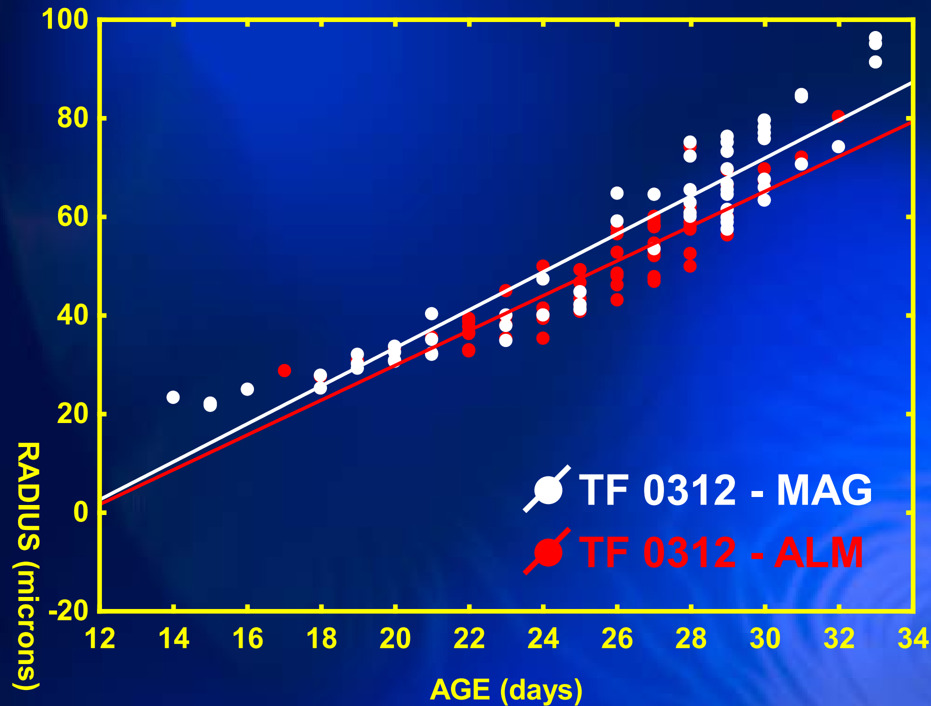
ANCOVA LOGDW vs AGE

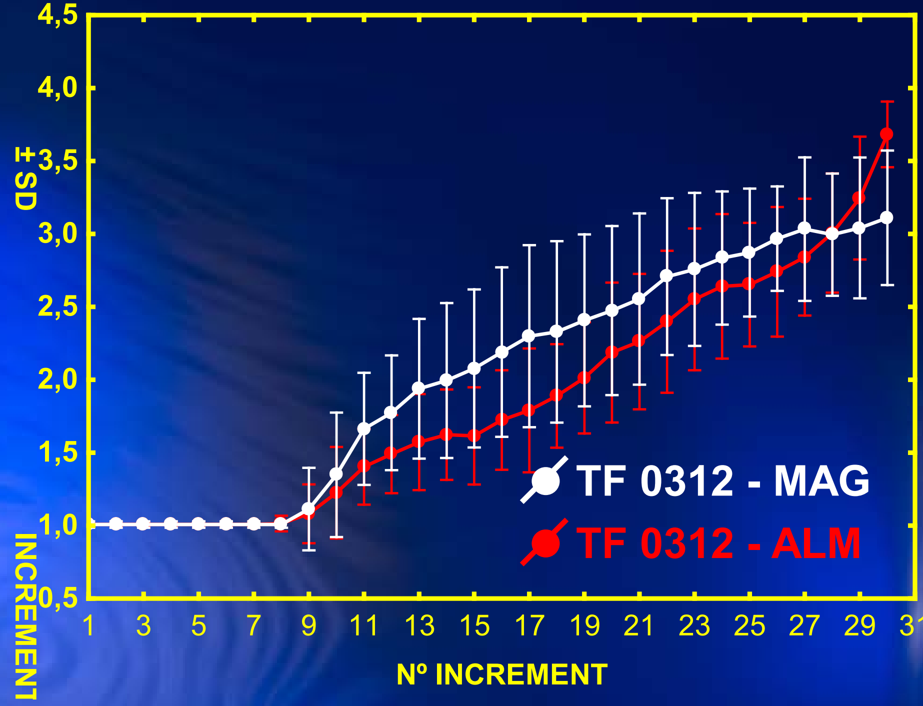
$F(1, 123) = 14.52; p < 0.01$

MAG > ALM

Larvae from MAG showed faster growth (SL & DW) than ALM

TF 0312 – *Otolith biometry*





ANCOVA RADIUS vs AGE

F (1, 123) = 25.01; p < 0.01

MAG > ALM

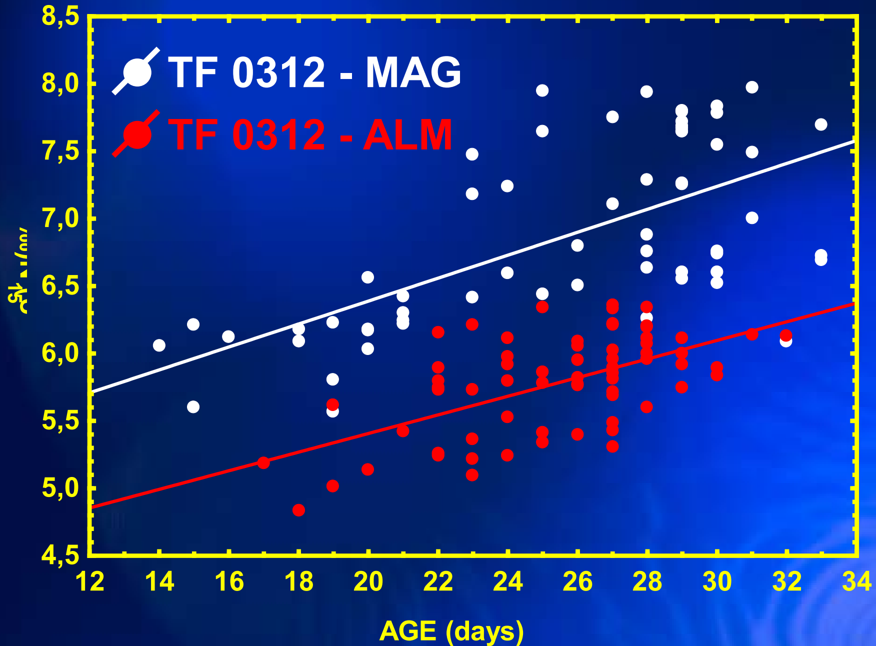
ANCOVA INC-MED vs AGE

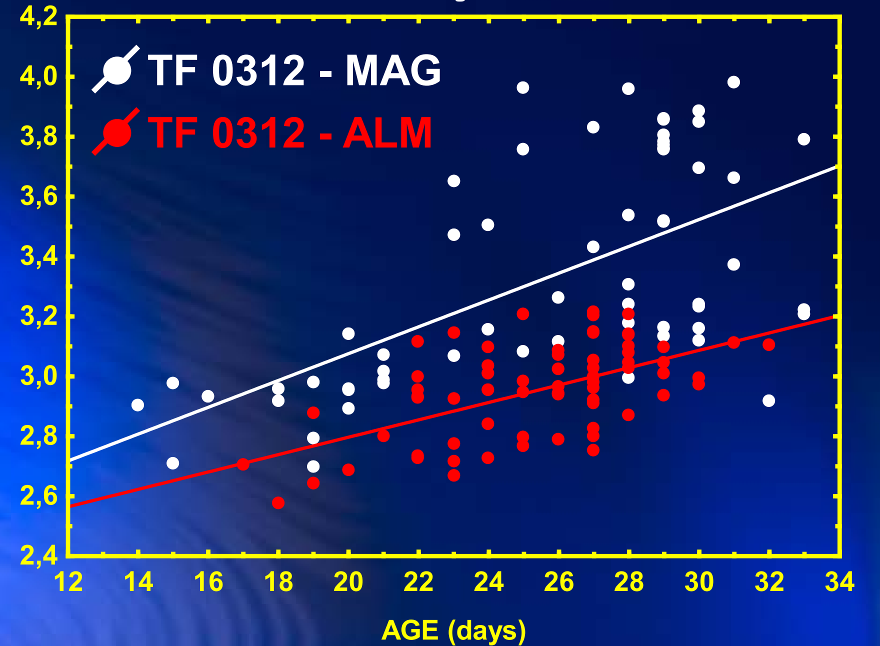
F (1, 123) = 49.71; p < 0.01

MAG > ALM

Larvae from MAG with higher growth showed also greater otoliths with wider increments in comparison with ALM population

TF 0312 – *Trophic variables*





ANCOVA δ^{15}N vs AGE

$F_{(1, 123)} = 201.98$; $p < 0.01$

MAG > ALM

ANCOVA TL vs AGE

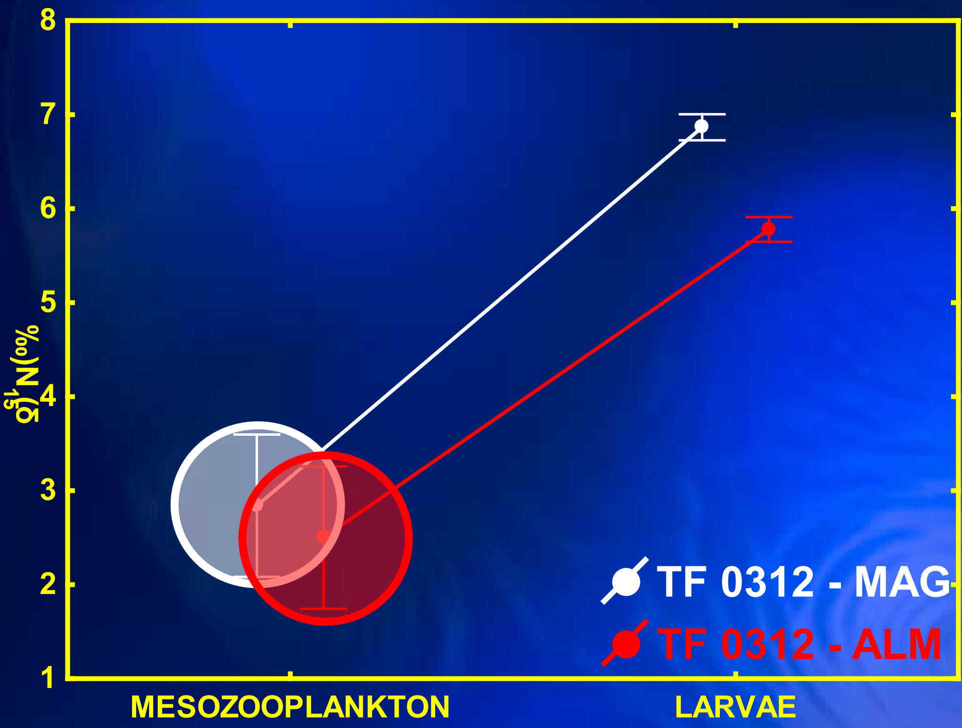
$F_{(1, 123)} = 82.77$; $p < 0.01$

MAG > ALM

In this case, larvae from MAG present higher values of δ^{15}N and higher Trophic Levels.

In both populations, δ^{15}N and Trophic Levels increase significantly with age resulting from changing trophic behavior with development

TF 0312 – *Trophic variables and the planktonic community*



No difference in the δ¹⁵N mesozooplankton fraction is associated with no differences in the planktonic community

Differences in δ¹⁵N between populations are exclusively due to different enrichment between larvae and their potential preys

Mesozooplankton	**MAG**	**ALM**
$\delta^{15}N$ (‰)	2.84	2.50
Biomass (mg/m^3)	16.98	17.60
Cladocera (ind/m^3)	5.25	50.50
Copepods (ind/m^3)	2498.38	549.32
Nauplius Copepods (ind/m^3)	186.71	54.86
Appendicularia (ind/m^3)	28.59	52.68

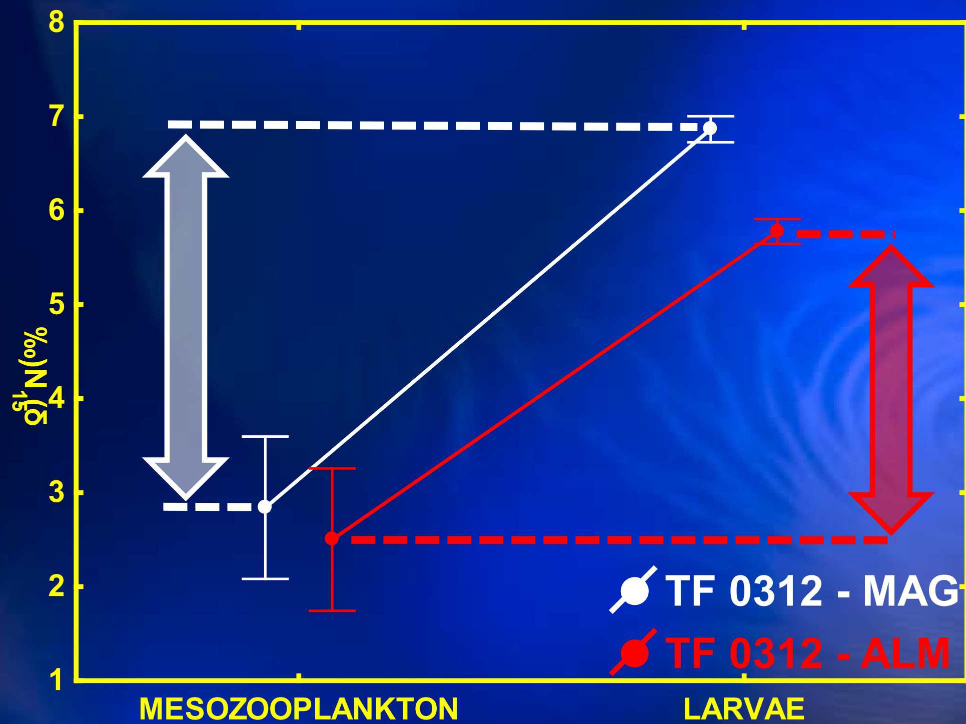
ANOVA

$p < 0.05$

$p < 0.1$

TF 0312 – *Trophic variables and planktonic community*

$$TL_{consumer}=TL_{basal}+(\delta^{15}N_{consumer}-\delta^{15}N_{prey})/\Delta\delta^{15}N$$



ENRICHMENT

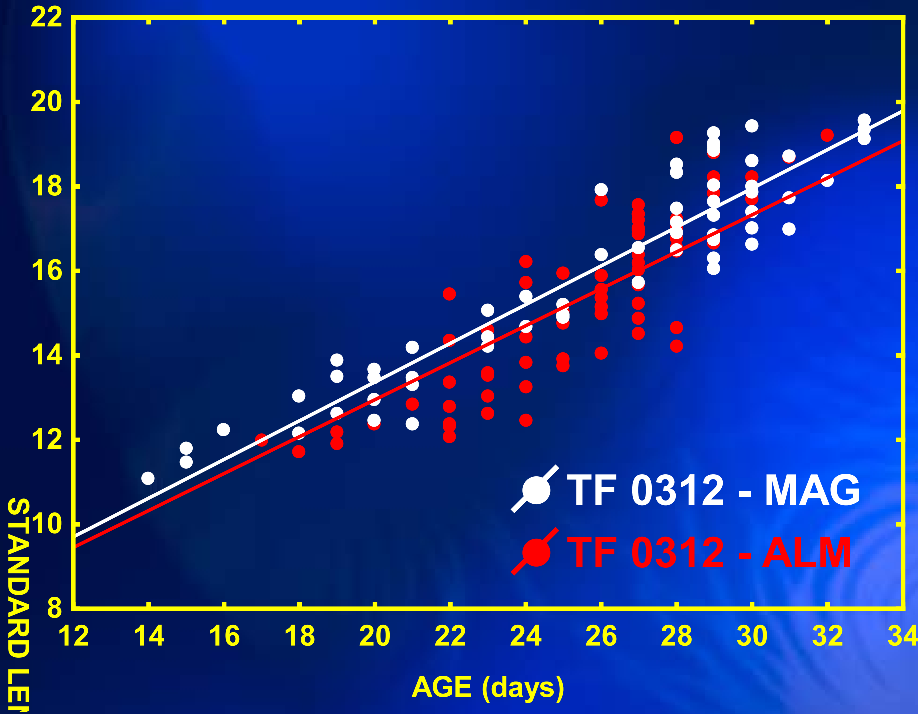
MAG 4.02±0.05

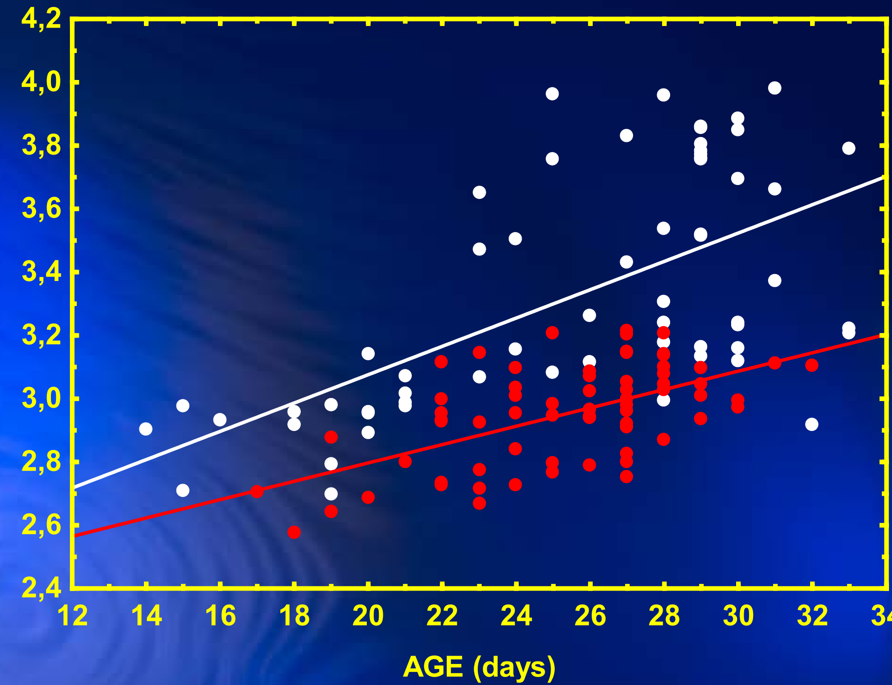
ALM 3.28±0.05

TROPHIC LEVEL

MAG > ALM

TF 0312 – *Growth patterns and Trophic variables*





ANCOVA SL vs AGE

$F(1, 123) = 11.22$; $p < 0.01$

MAG > ALM

ANCOVA TL vs AGE

$F(1, 123) = 82.77$; $p < 0.01$

MAG > ALM

Larvae with higher Trophic Levels showed faster growth

Conclusions

Sardine larvae show significant increases of $\delta^{15}N$ values and increased trophic level with age as a consequence of dietary changes throughout ontogenic development.

Higher trophic position has significantly influenced faster somatic growth expressed by greater body size and weight.

Greater growth potential is significantly related to the otolith biometrics.

$\delta^{15}N$ of sardine larvae is conditioned by the seasonal plankton community structure particular to each nursery area, while TL is influenced by larval trophodynamics.

Feeding ecology is a significant driving factor influencing growth variability in sardine early life stages.


THANKS FOR
YOUR ATTENTION