

Advances in the knowledge of condition and energy budgets along the life cycle of two small pelagic fishes from the Western Mediterranean

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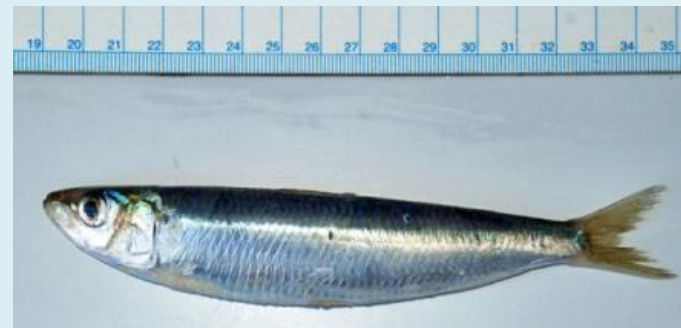
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Small pelagic fishes (SPF): Which is their role?

- Shoaling, plankton-feeding epipelagic fishes of 10-30 cm in length.
- Major contributors of the world total landings.
- Population dynamics is highly subject to environmental variability.
- Significant biomass at intermediate levels of food web.
- SPF are a key group, transferring energy from the lower to the higher trophic levels.
- The two most important SPF species in NW Mediterranean:
 - European anchovy (*Engraulis encrasicolus* L.)
 - European sardine (*Sardina pilchardus* Walb.)



Engraulis encrasicolus



Sardina pilchardus

Bioenergetics modelling

Bioenergetics

Study of energy intake and its transformations within the organism and through ecosystem

Bioenergetic models

Used in fisheries science and ecology to understand and predict individuals, populations and ecosystem responses to impacts

- ✓ Different models have been applied to marine organisms based on the energy intake and its use for somatic maintenance, growth and reproduction.
- ✓ Parameters required can be estimated by laboratory analyses.
- ✓ Lack of species and ecosystem specific data leads to the borrowing of parameters from other species and regions, as for the current anchovy models.

SPF bioenergetics

- ✓ Lipids in muscle are a principal energy reserve.
- ✓ Lack of knowledge about energy partition between growth and reproduction.
- ✓ Reproductive strategies: income and capital breeder.

Objectives

Anchovy vs. Sardine

Comparison of their strategies in the use of resources to spawning activity over a year

Anchovy

Analysis of seasonal variability of energy content in anchovy individuals and gonads

Material and Methods: Sampling



Monthly sampling (April 2012 – March 2013) of anchovy and sardine in Ebro delta continental shelf (NW Mediterranean)

Because of the high productivity of these shelf waters, Ebro delta continental shelf is an important spawning ground of anchovy and sardine

Material and Methods: Dissections

**All fishes were dissected (1318 anchovies, 1231 sardines)
Sex was determined and diverse parameters were measured.**

Biometric data:

Total length (TL)
Standard length (SL)
Total weight (TW)
Gutted weight (GW)
Gonad weight (W_G)
Liver weight (W_L)

Macroscopic maturity stage:

1 = immature/rest
2 = developing
3 = imminent spawning
4 = spawning
5 = post-spawning
6 = spent

Fat index for sardine, (fat surrounding the gut)

1 = not fat visible
2 = thin thread of fat
3 = thicker layer of fat
partially surrounding
4 = thicker layer of fat
surrounding the gut

Material and Methods: Anchovy and sardine

Non-linear models fitting:

TL – TW relationship

Minimum condition



$$TL = a \cdot TW^b$$

Monthly estimations for adult individuals of:

Somatic condition (relative weight, W_r)

Gonadosomatic index (GSI, %)

Hepatosomatic index (HSI, %)

Seasonal lipid content in muscle

80 samples of each species (20 per season)

Lipid extraction by Folch method (Folch et al., 1957)

Lipid content expressed as %lipids per g of wet weight

Material and Methods: Anchovy energy density analyses

All energy density (ED) analyses were performed by Oxygen Bomb Calorimeter

Whole fish:

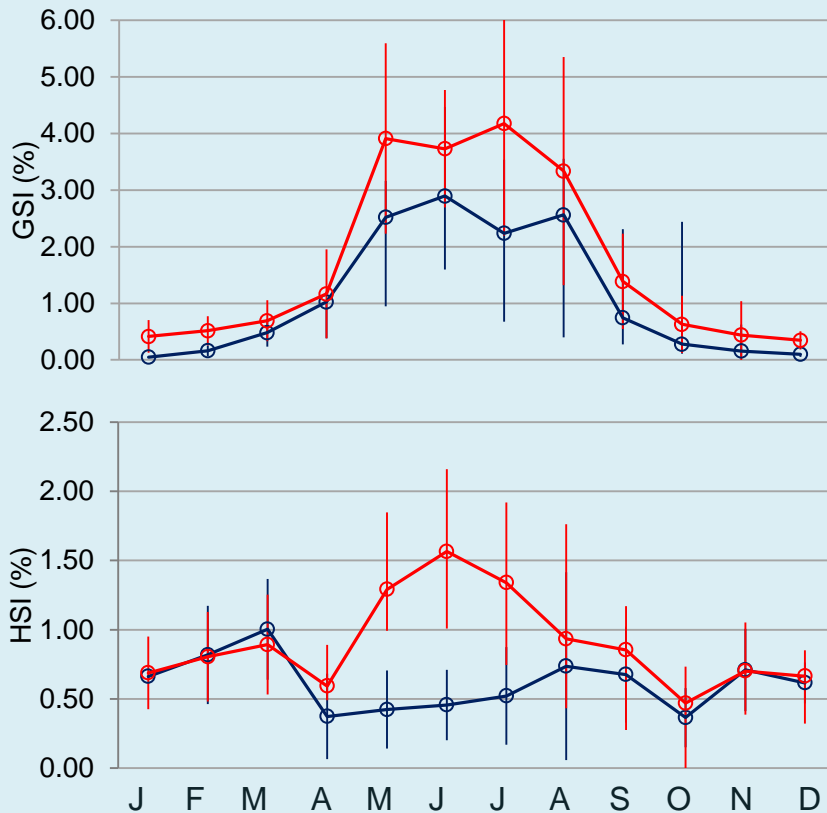
- ✓ Individuals of TL > 9 cm
- ✓ 20 individuals per season
- ✓ 2 subsamples per individual
- ✓ Measures performed on dried tissue
- ✓ Results expressed on a wet weight basis

Gonads:

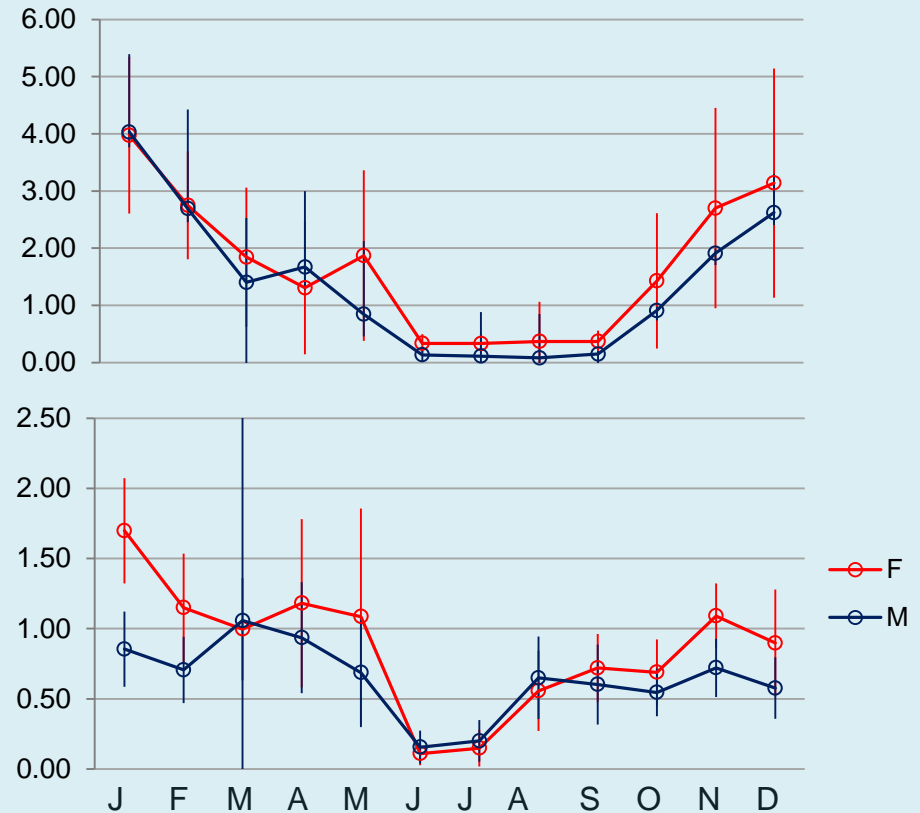
- ✓ Gonads were grouped by sex, TL and maturity stage
- ✓ 2 subsamples per gonad or group
- ✓ Measures performed on dried tissue
- ✓ Results expressed on a wet weight basis

Results & Discussion: GSI and HSI

Anchovy



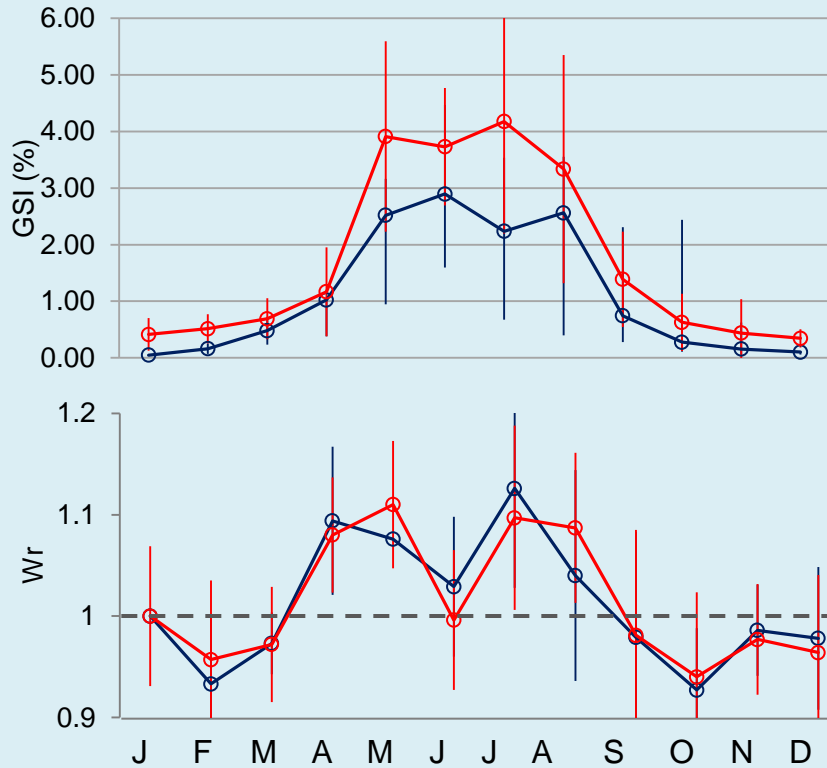
Sardine



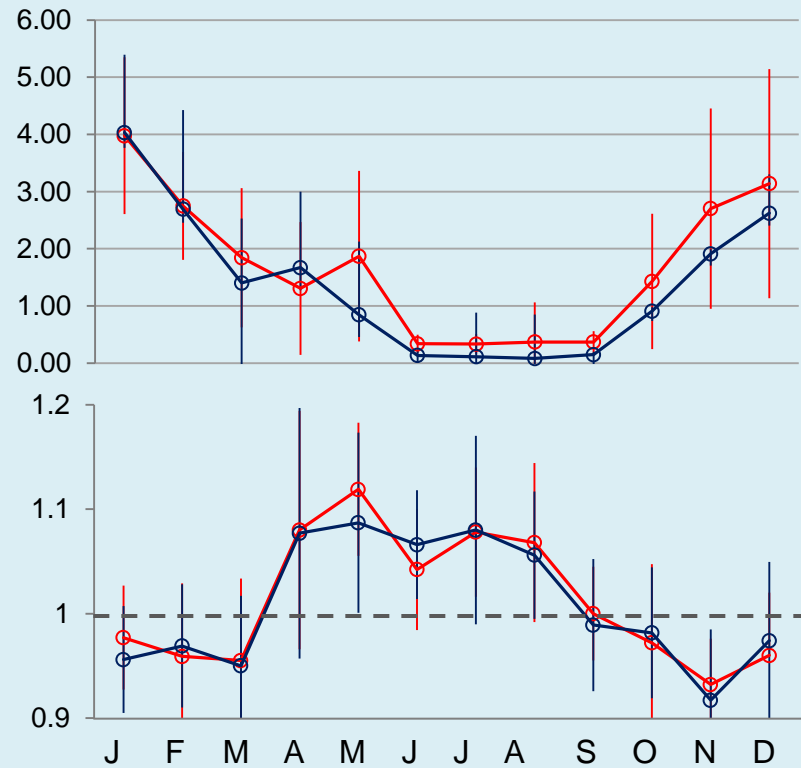
- ✓ Inverse trend in the reproductive activity of anchovy and sardine.
- ✓ Sardine showed secondary reproductive activity in April and May.
- ✓ Within spawning season, HSI was higher in females of both species.

Results & Discussion: GSI and condition

Anchovy

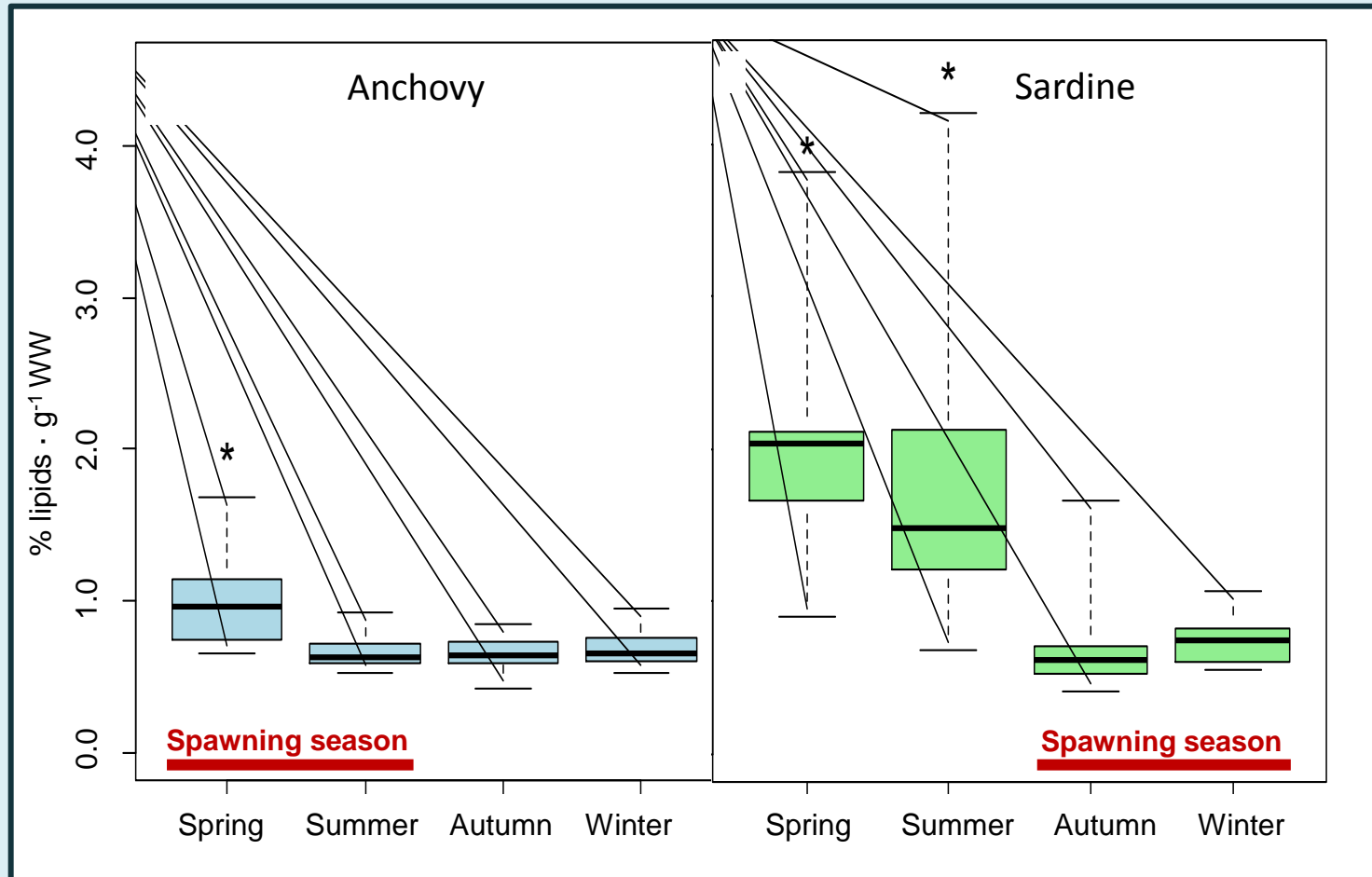


Sardine



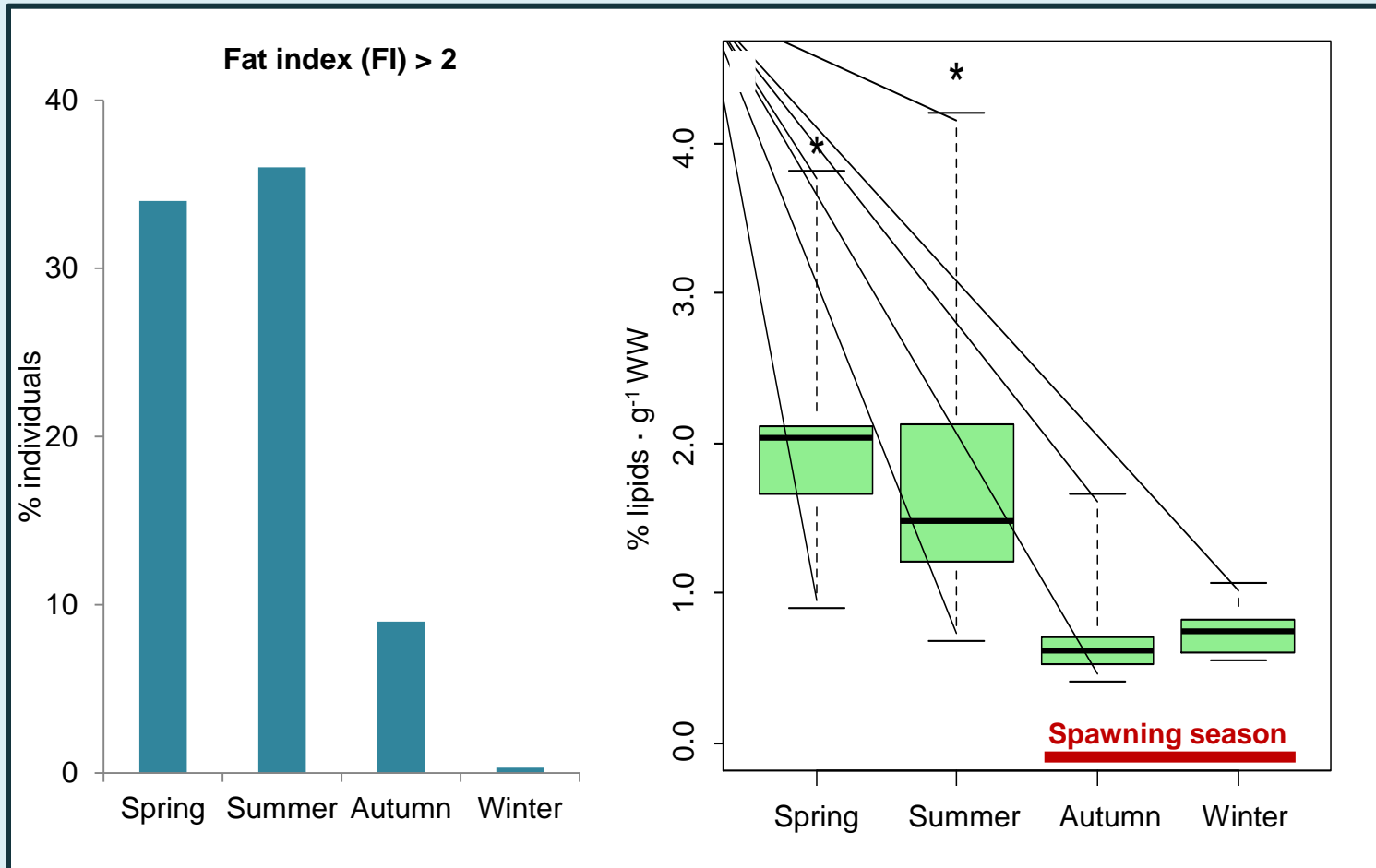
- ✓ Maximum condition recorded in spring and summer for both species (drop in June).
- ✓ **Anchovy:** Condition and GSI had the same trend → **income breeder.**
- ✓ **Sardine:** Condition and GSI had inverse trend → **capital breeder.**

Results & Discussion: Muscle lipid content



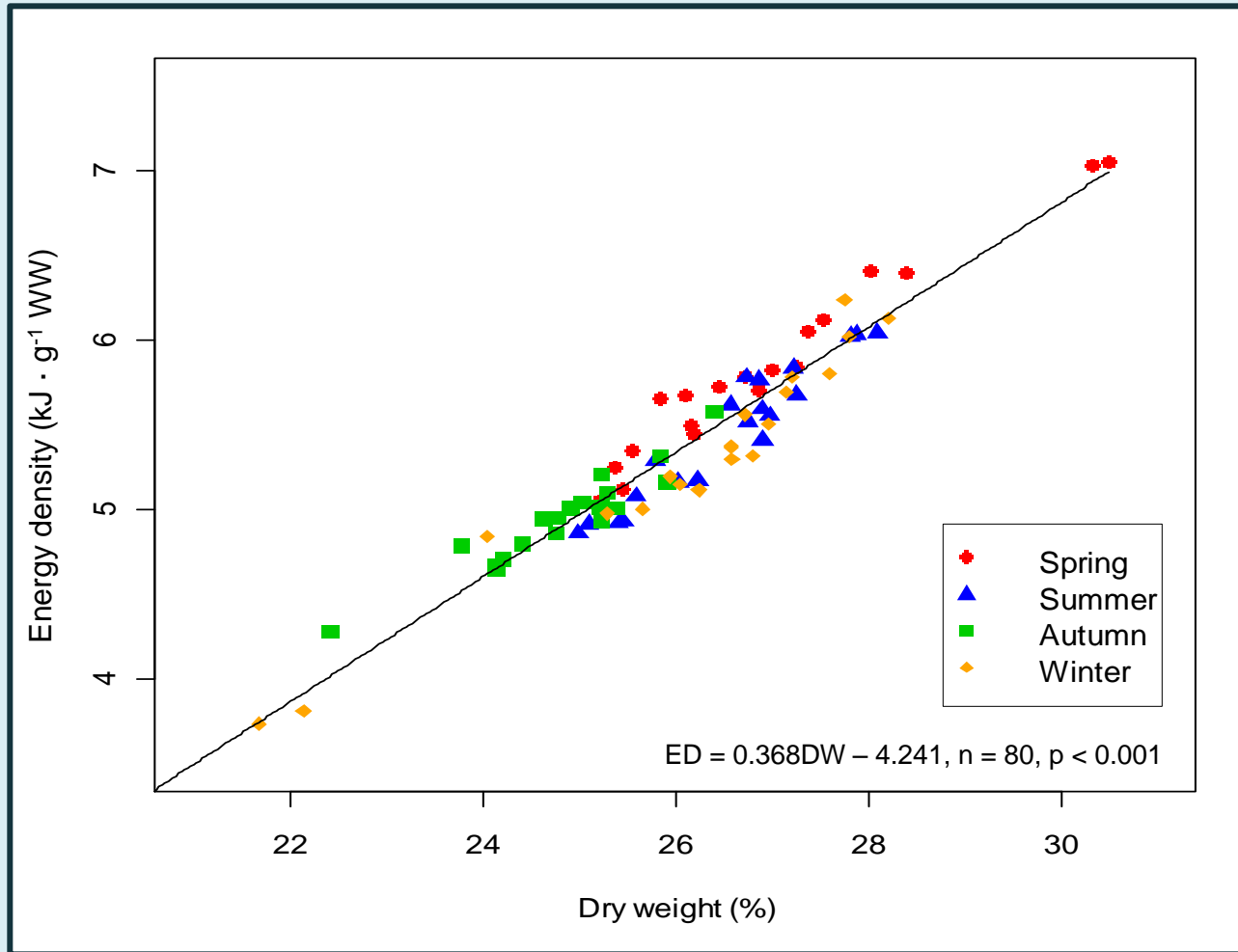
- ✓ Lipid content in anchovy is lower and less variable than in sardine.
- ✓ No differences between sexes.
- ✓ **Sardine:** Positive correlation between size and lipid content.

Results & Discussion: Muscle lipid content in sardine



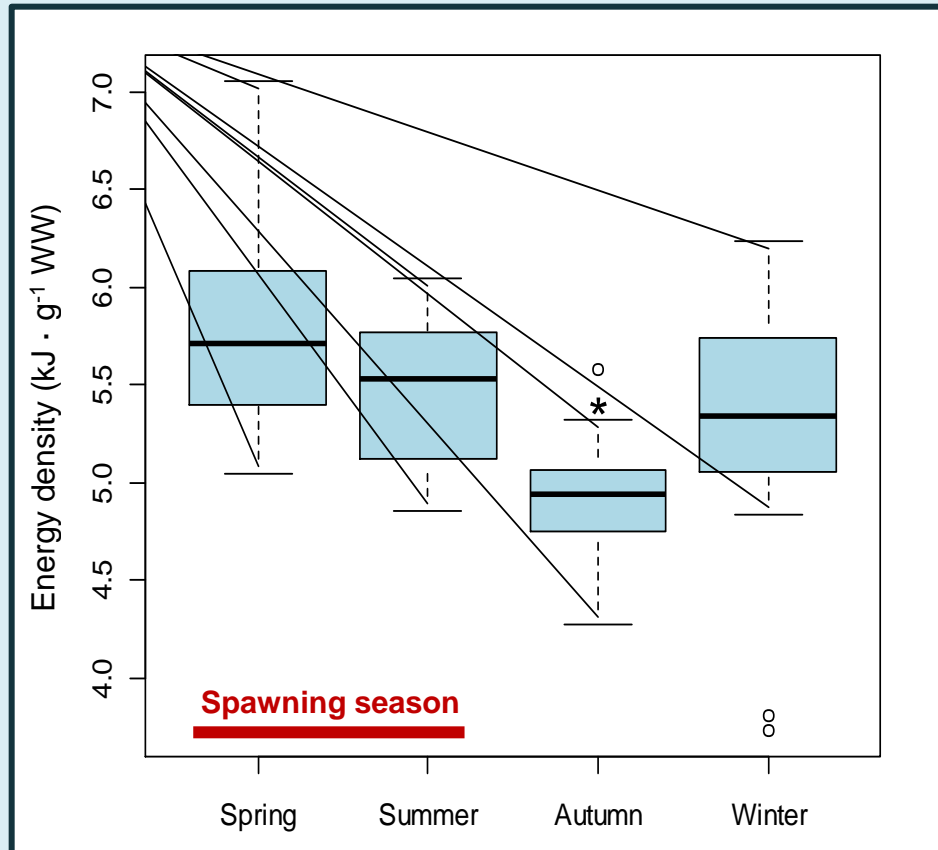
- ✓ Mesenteric fat and lipid storage in muscle followed the same trend.
- ✓ Steep drop in lipid content and FI before spawning.
- ✓ Energy storage prior spawning activity.

Results & Discussion: Anchovy energy density



- ✓ As %DW increased (i.e. water content decreased), ED increased as well.
- ✓ This relationship is species and ecosystem specific.
- ✓ Useful tool to determine ED knowing %DW.

Results & Discussion: Anchovy energy density



- ✓ ED values are in accordance with other studies.
- ✓ Minimum ED in autumn, after spawning season (contrary to studies of Adriatic sea and Bay of Biscay).

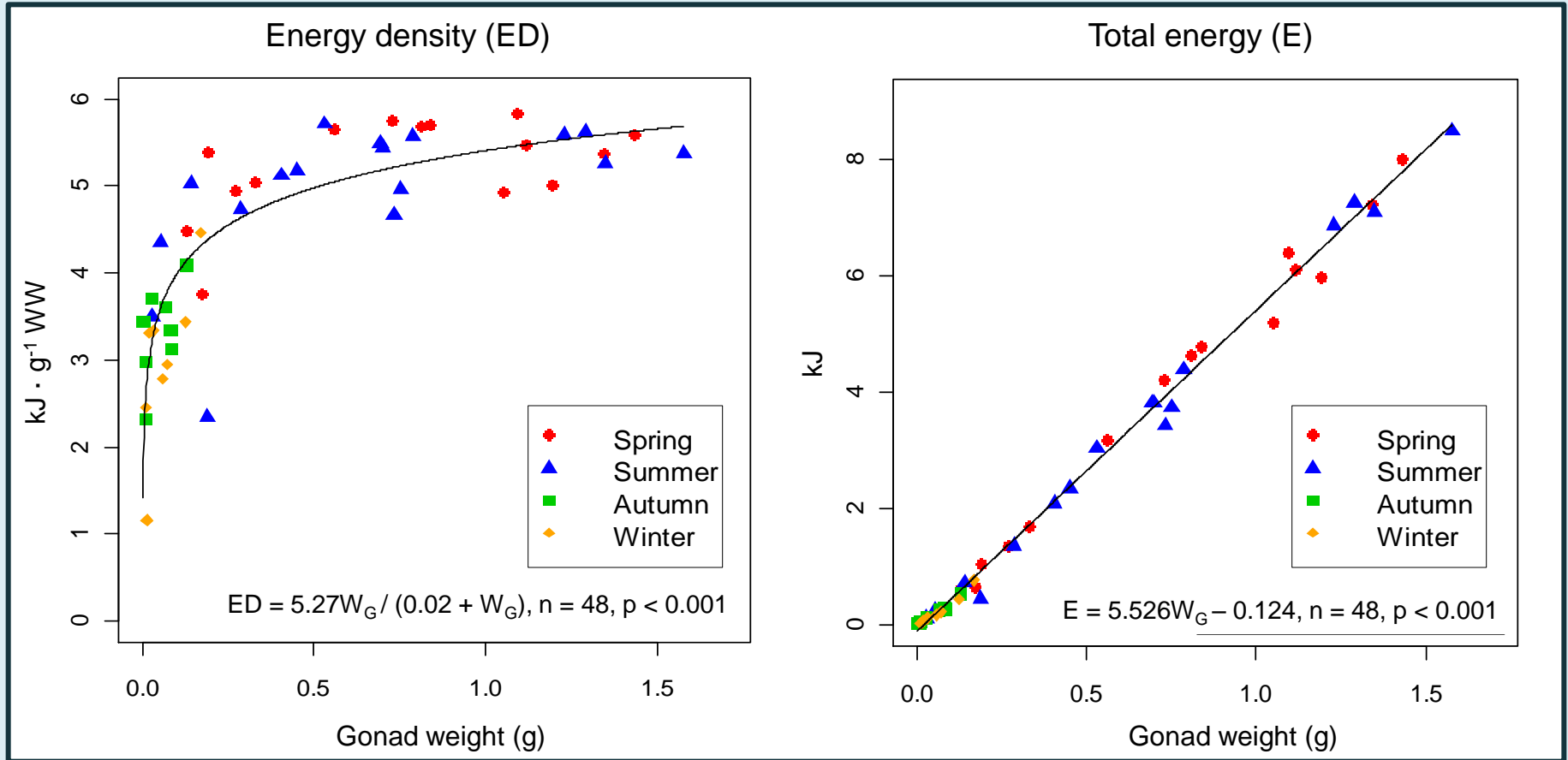


Did food input provide enough energy?

If not:

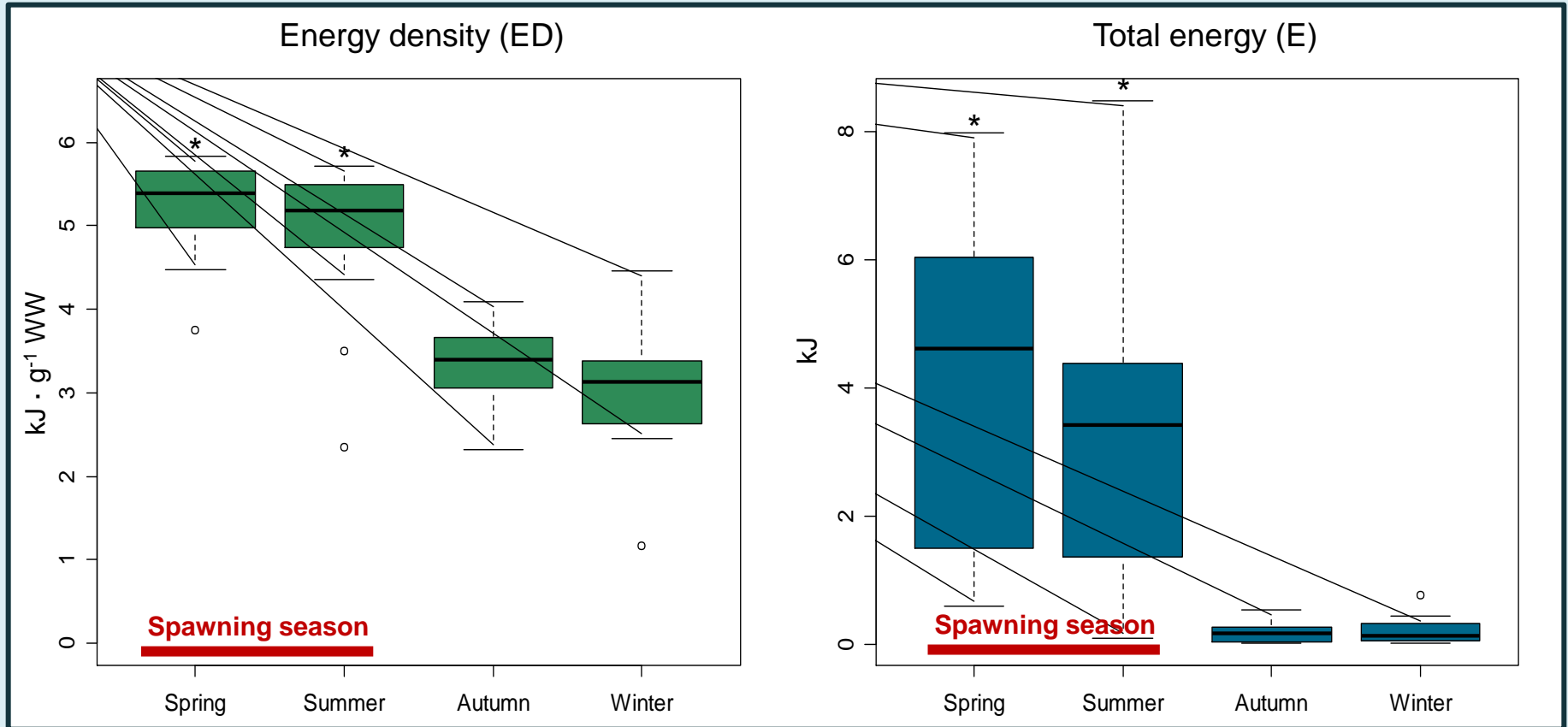
- Unfavourable conditions this year?
- Specific pattern in Ebro delta shelf?

Results & Discussion: Energy of anchovy gonads



- ✓ ED increased rapidly with increasing gonad weight up to 0.25 g, then remained relatively constant (and individuals were reproductively active).
- ✓ E increased linearly with the gonad weight.

Results & Discussion: Energy of anchovy gonads



- ✓ High energy allocation to gonads during spawning season.
- ✓ ED and E were significantly higher during spawning season

Concluding...

- Study of condition, GSI and muscle lipid content show that:
 - ✓ **Sardine** deploys mainly capital breeder strategy.
 - ✓ **Anchovy** deploys income breeder strategy.
- Analyses of ED show that:
 - ✓ ED remains high during spawning season → income breeder.
 - ✓ ED decreases after spawning season, different to other studies, but the reason is not clear.
 - ✓ High energy allocation to gonads during spawning season.

Further studies...

- More efforts are needed to analyze differences in allocation processes between sexes and maturity stages.
- This work provides:
 - ✓ Useful tools to further studies in caloric content in NW Mediterranean anchovy.
 - ✓ Most of the elements needed to apply species specific bioenergetic models in the study area.
- Estimating the same data for sardine would allow to study the reproductive ecology and the influence of environmental variables in reproductive success.

Acknowledgments

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