Calibration of the DEB model for small pelagics. What data is needed and at which timescale?

Paul Gatti, Pierre Petitgas, Martin Huret

Victoria, BC, Canada
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DEB: *Dynamic Energy Budget*

Model energy fluxes

Predict : development / growth / spawning / mortality

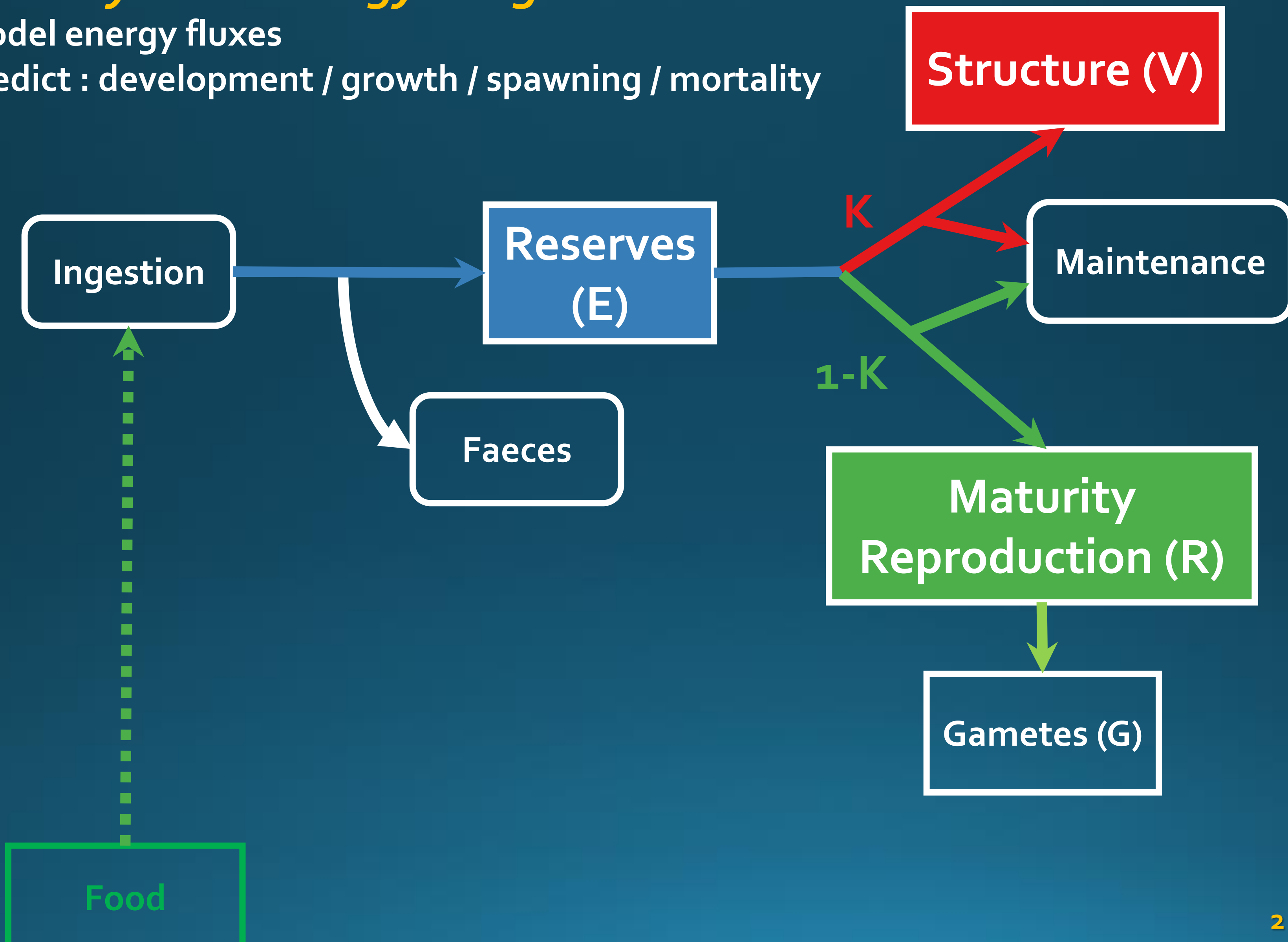

Table 3
The completeness of available data can be ranked with marks from low to high at the following levels; each level includes previous levels.

0	Maximum length and body weight; weight as function of length
1	Age, length and weight at birth and puberty for one food level; mean life span (due to ageing)
2	Growth (curve) at one food level: length and weight as functions of age at constant (or abundant) food level
3	Reproduction and feeding as functions of age, length and/or weight at one food level
4	Growth (curve) at several (>1) food levels; age, length and weight at birth and puberty at several food levels
5	Reproduction and feeding as functions of age, length and/or weight at several (>1) food levels
6	Respiration as function of length or weight and life span at several (>1) food levels
7	Elemental composition at one food level, survival due to ageing as function of age
8	Elemental composition at several (>1) food levels, including composition of food
9	Elemental balances for *C*, *H*, *O* and *N* at several body sizes and several food levels
10	Energy balance at several body sizes and several food levels (including heat)

<u>Lika et al. 2011.</u> The "covariation method" for estimating the parameters of the standard Dynamic Energy Budget model I: Philosophy and approach

1. Introduction

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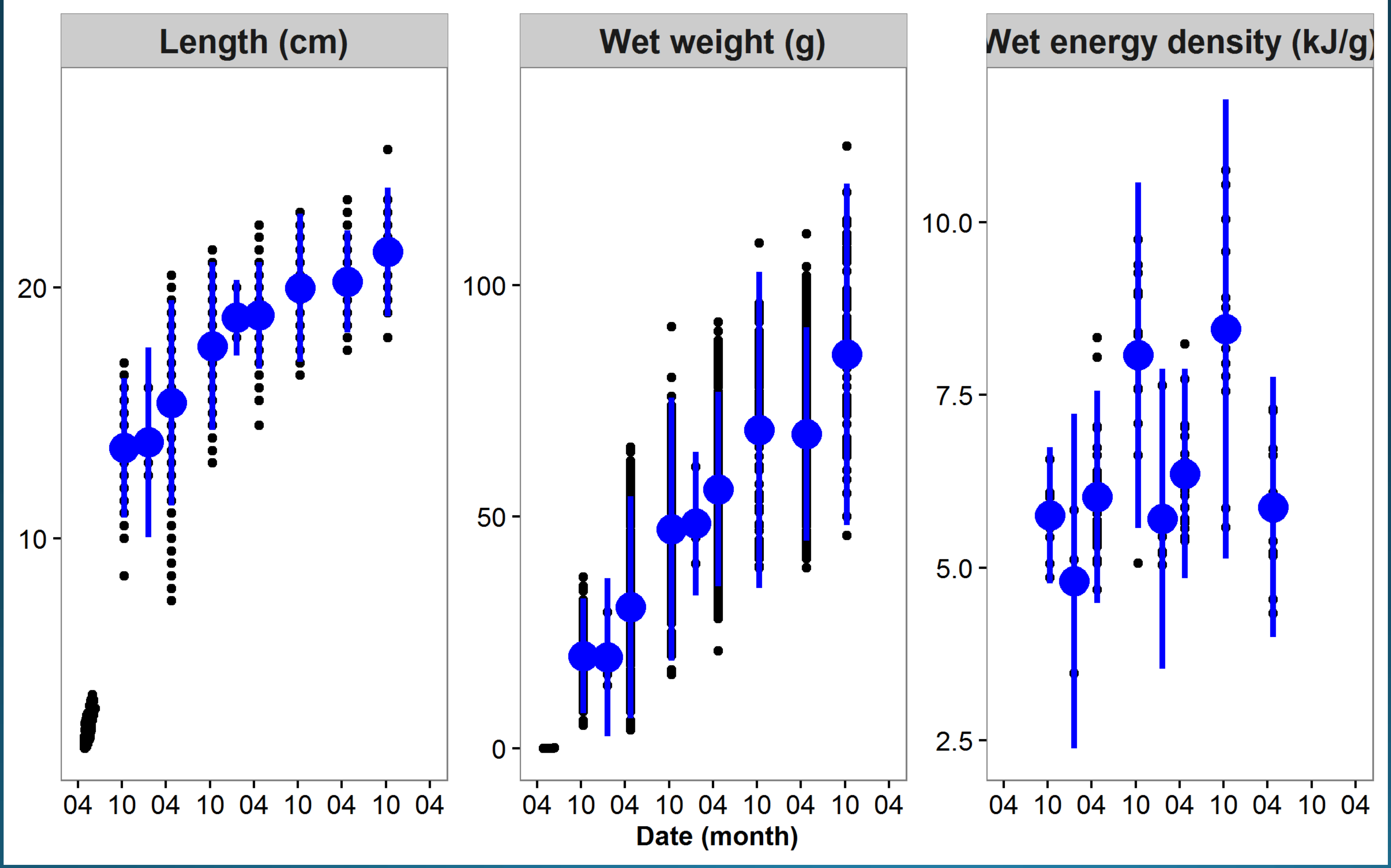
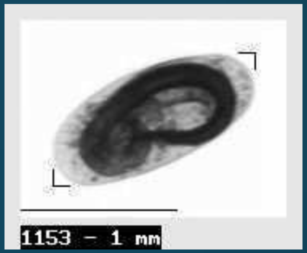
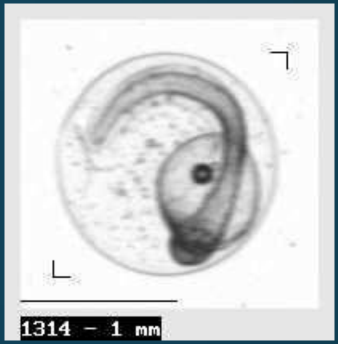
1. Length , Weight = f(age)
2. Feeding rate = f(age)
3. Reproduction = f(age)
4. Respiration = f(length)
5. Elemental composition
6. Energy balance

<u>Lika et al. 2011.</u> The “covariation method” for estimating the parameters of the standard Dynamic Energy Budget model I: Philosophy and approach

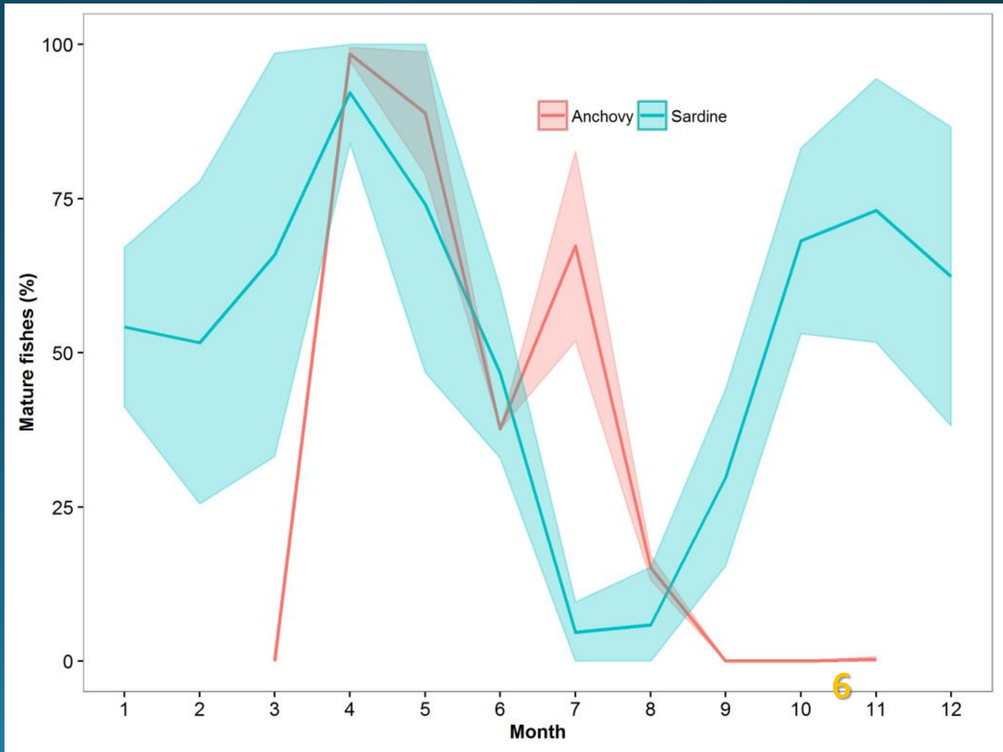
1. Length & weight at age (data)
2. Energy density measurements (data)







1. Length & weight at age (data)
2. Energy density measurements (data)
3. **Spawning investment (literature + data)**
    1. **Spawning window & duration (data + literature)**
    2. **Spawning frequency (literature)**
    3. **Relative batch fecundity (literature)**
    4. **Egg energy content (literature)**



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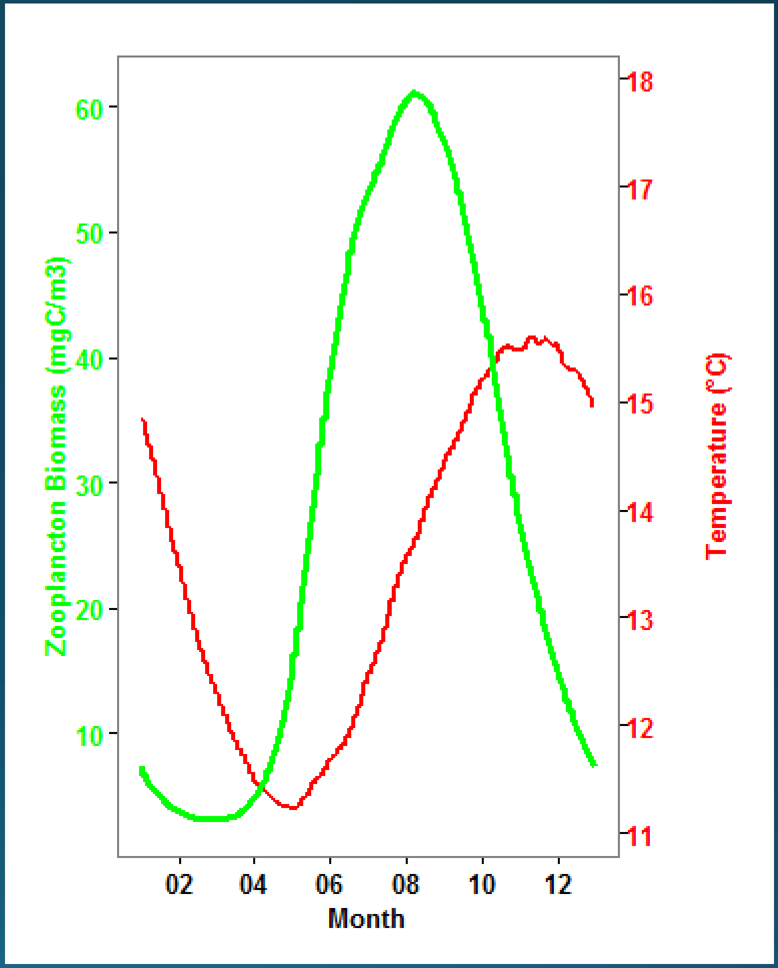
2. Energy density measurements (data)
3. Spawning investment (literature + data)
4. **Environmental forcing (model ECO-MARS3D)**



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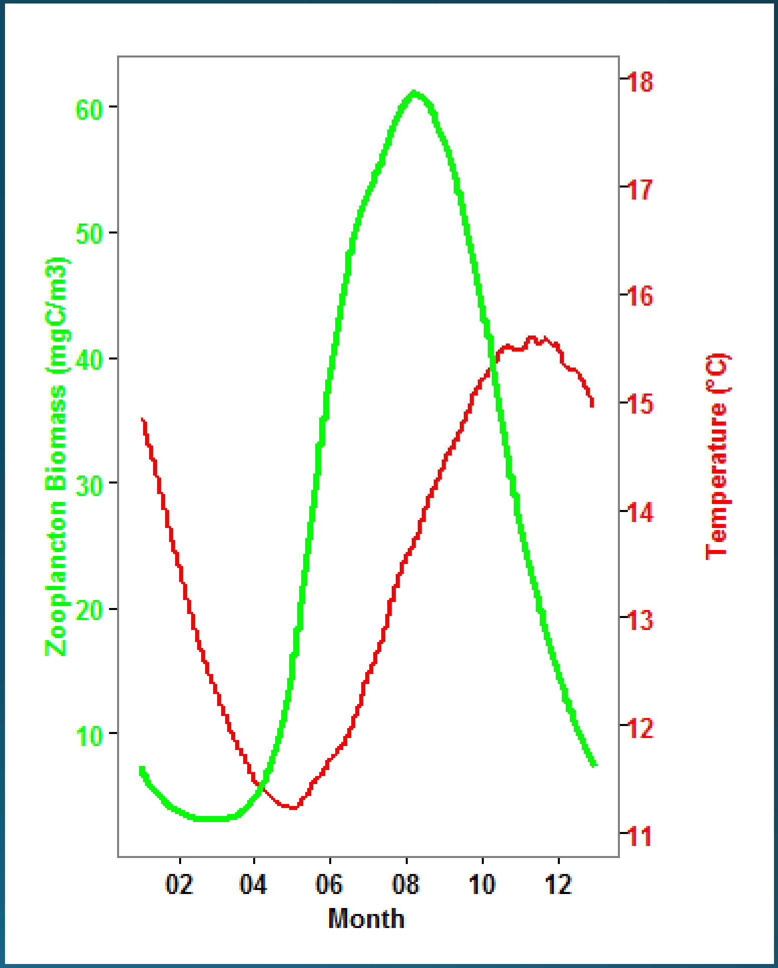
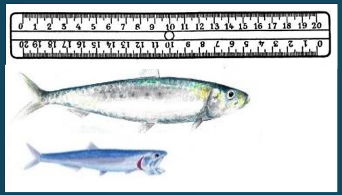


~ average data completeness

3 main differences: Size, spawning & feeding

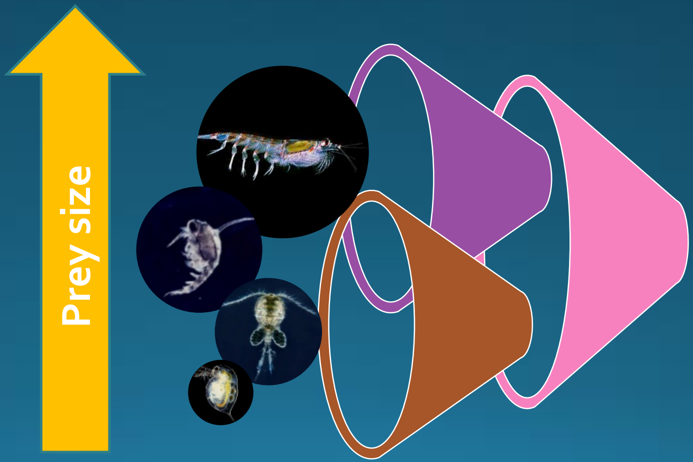
From anchovy to sardine: 3 sets of successive calibration scenarios

1. Size

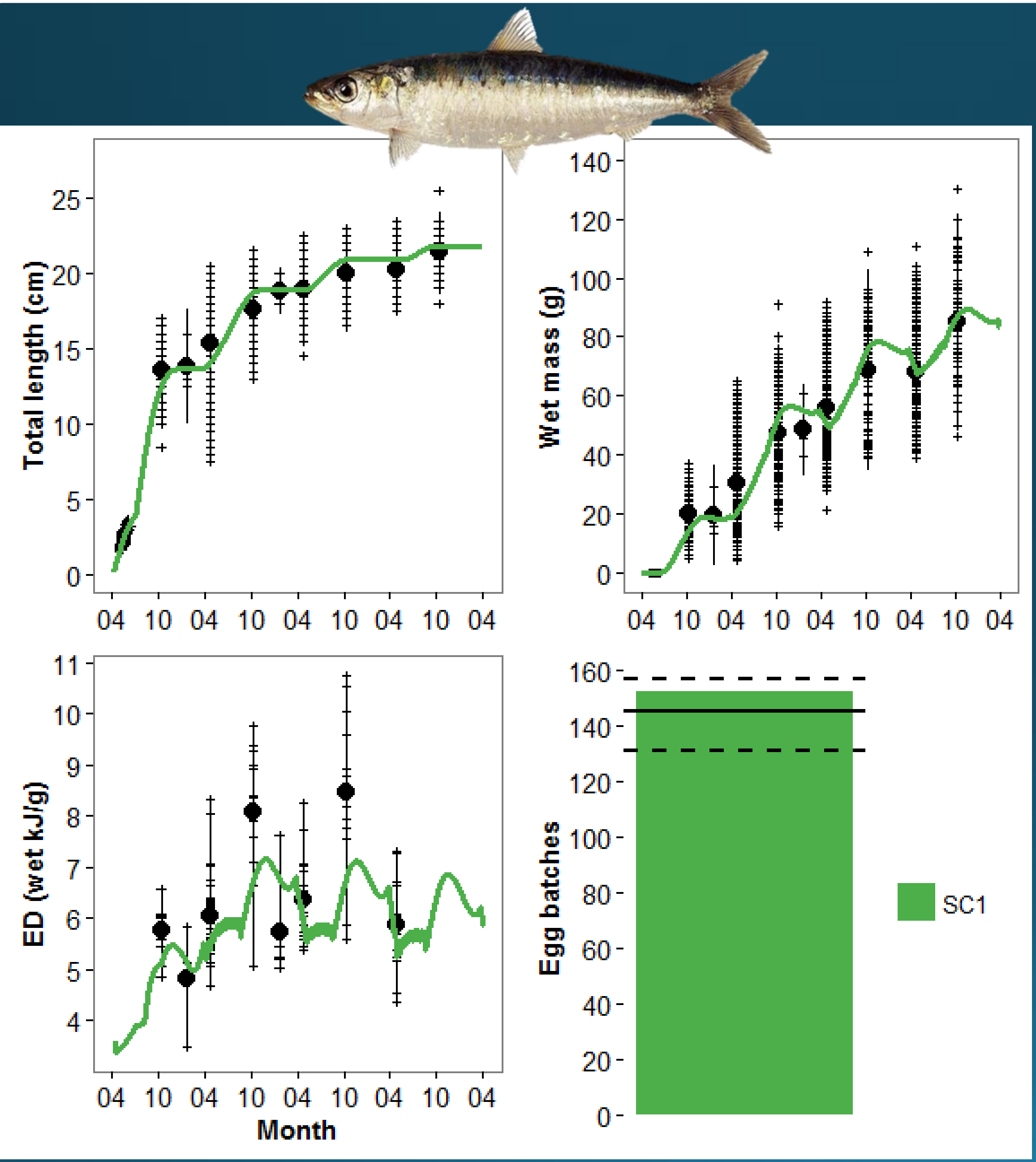


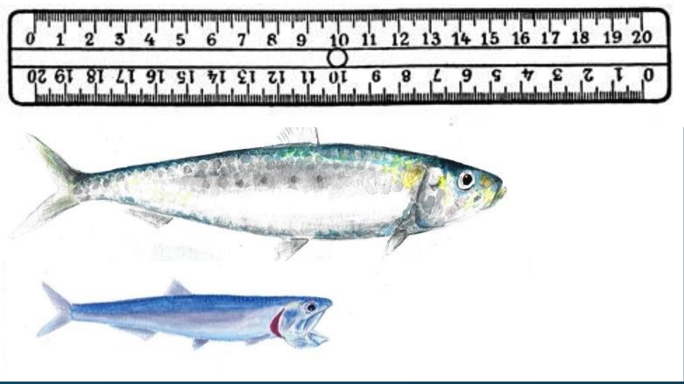
2. Size + Spawning

3. Size + Spawning + Feeding



Model fit

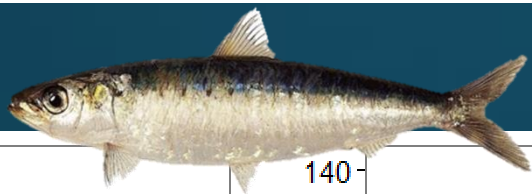


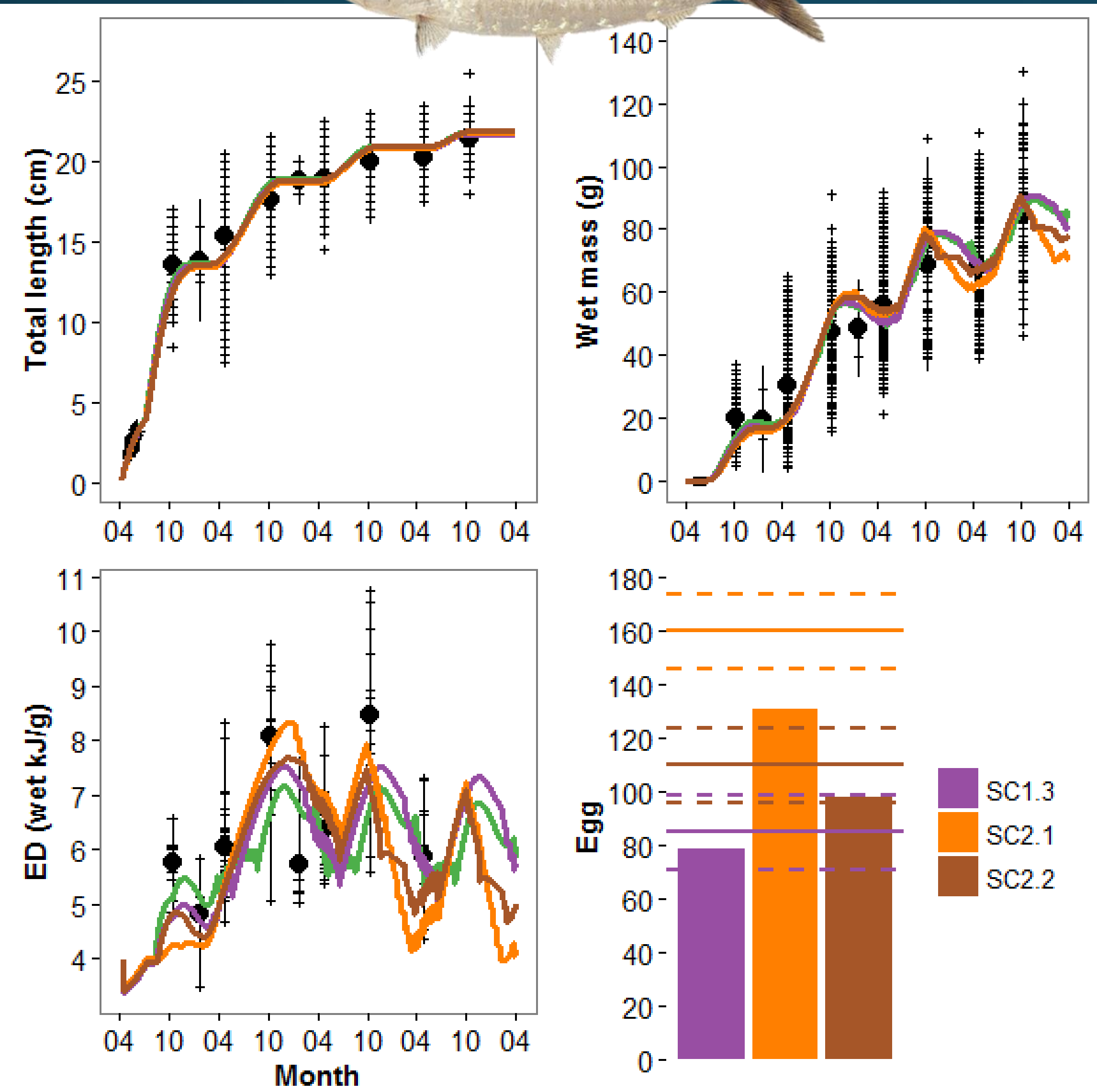


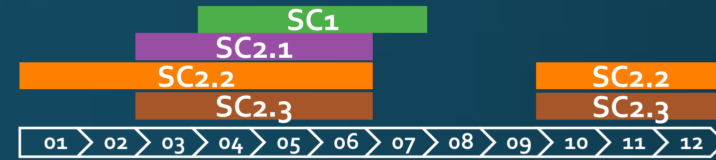
SC1 : Size

- Correct size & weight predictions
- Underestimate ED variability

Sardine ≠ « big anchovy »







SC2 : Size & Spawning

SC1 : Spring anchovy

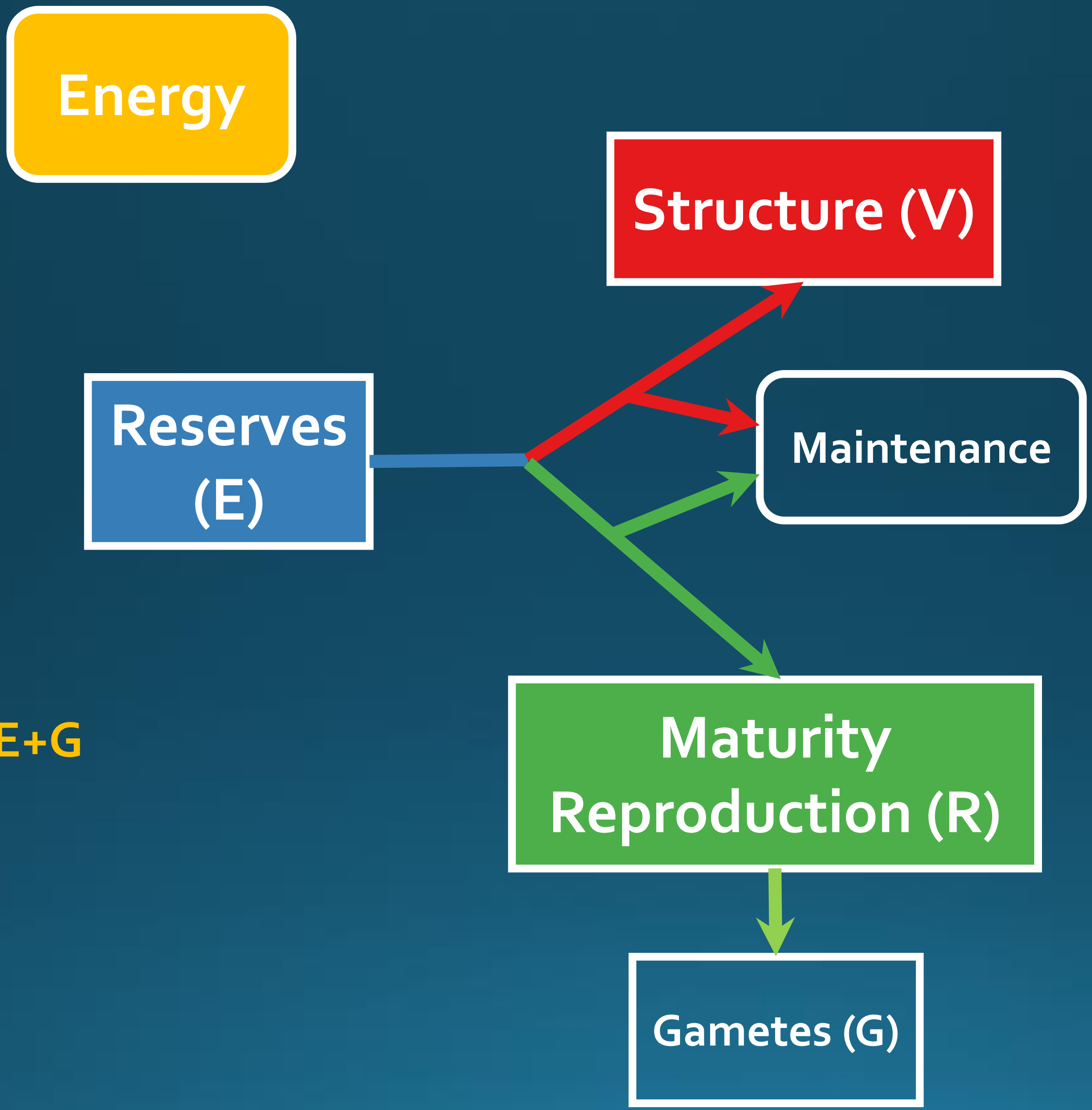
SC2.1 : Spring

SC2.2 : From autumn to spring

SC2.3 : Spring & autumn

- Size & weight predictions ≃
- **Better ED predictions**

3. Why is energy data so important ?



Energy=V+R+E+G

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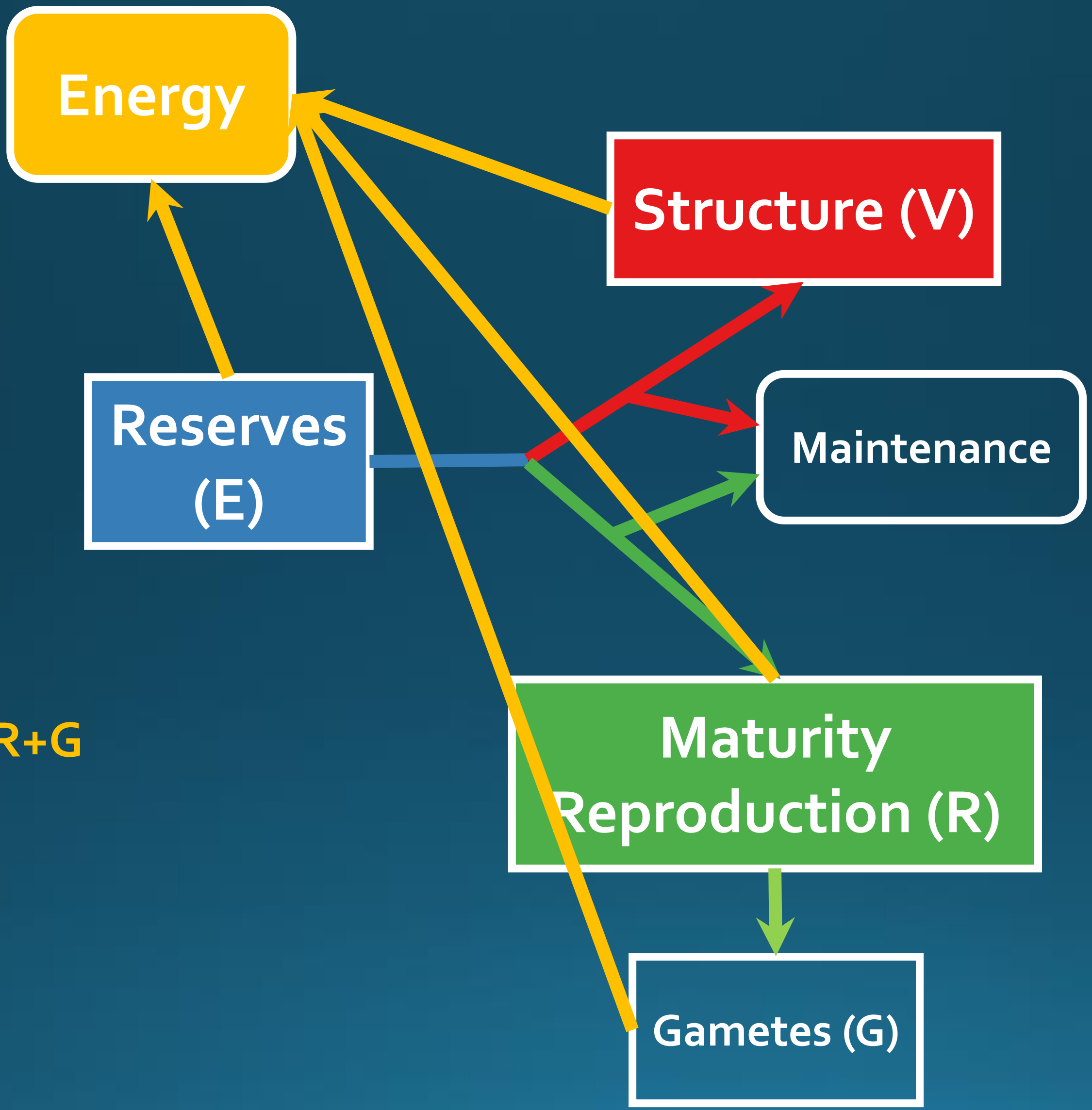

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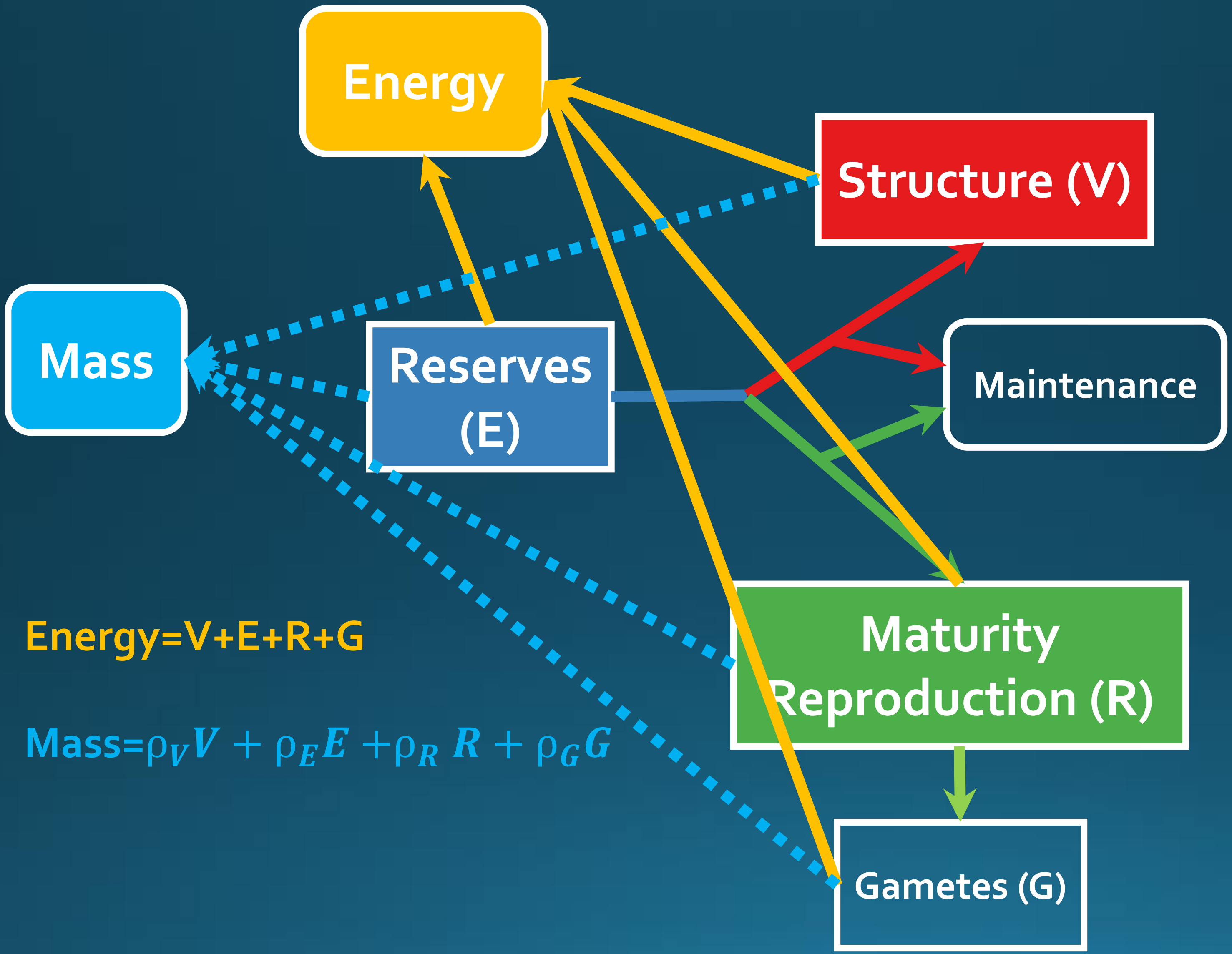

Energy=V+E+R+G

Mass=$\rho_V V + \rho_E E + \rho_R R + \rho_G G$

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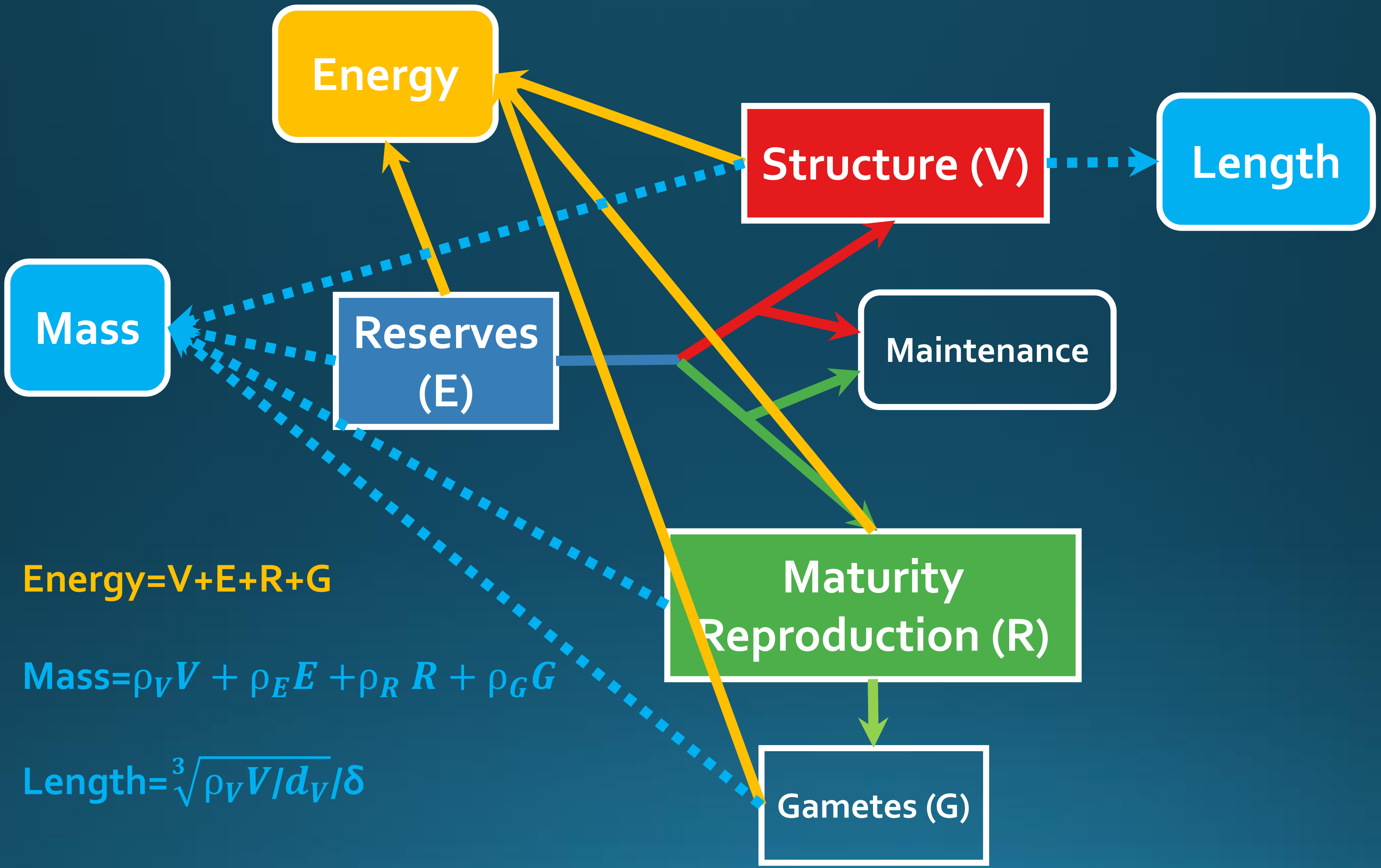


Energy=V+E+R+G

Mass=$\rho_V V + \rho_E E + \rho_R R + \rho_G G$

Length=$\sqrt[3]{\rho_V V / d_V} / \delta$

3. Why is energy data so important ?

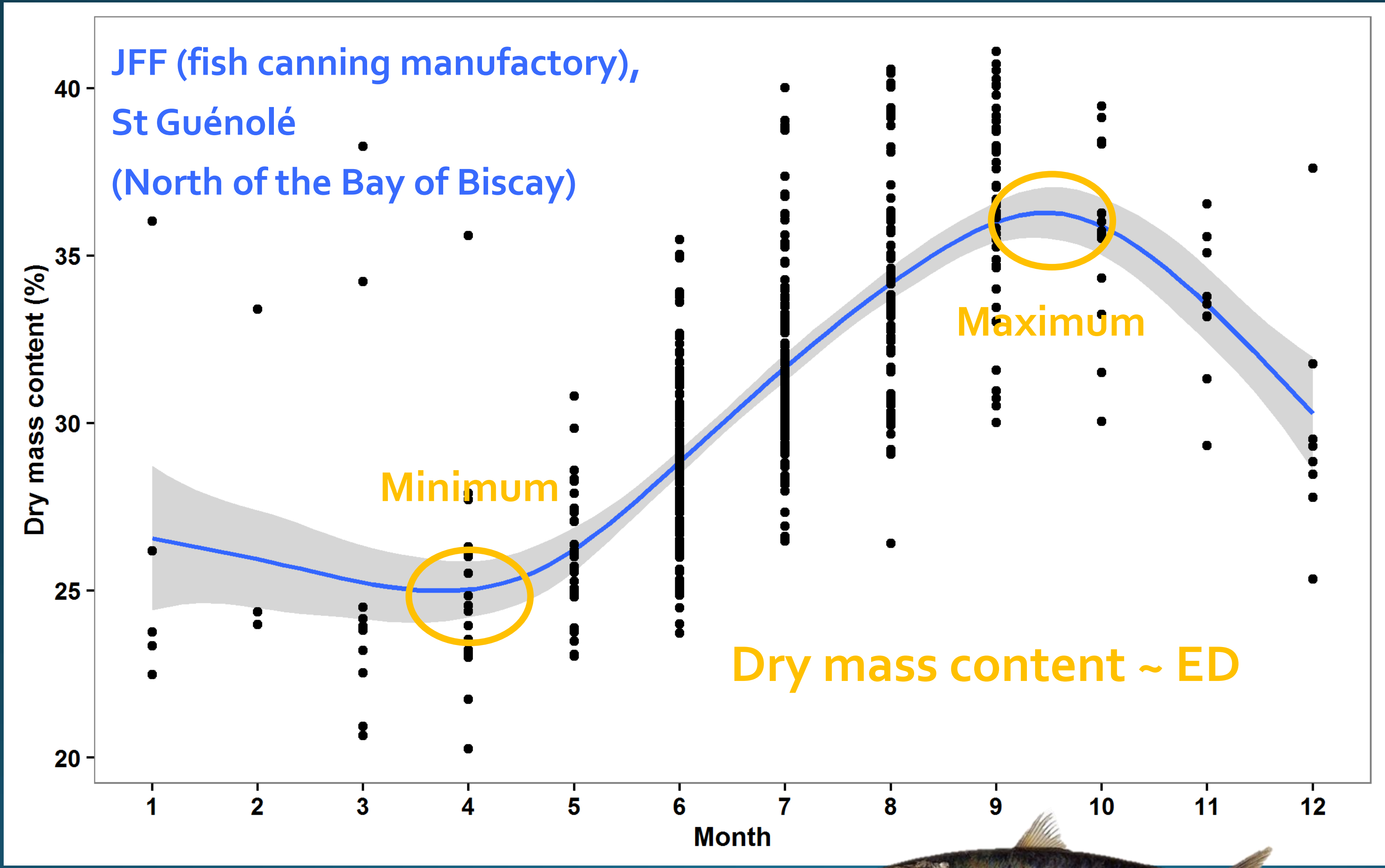
- Energy content data is needed …
- …except if you know the chemical composition of the fish

Chemical (proximal) composition

Water + **Minerals (ash)** + **Proteins** + **Lipids** ~ 100 %

- **Water** & **Minerals** → no energy
- **ED = weighted mean of lipids and proteins contents**

4. Which time scale ?



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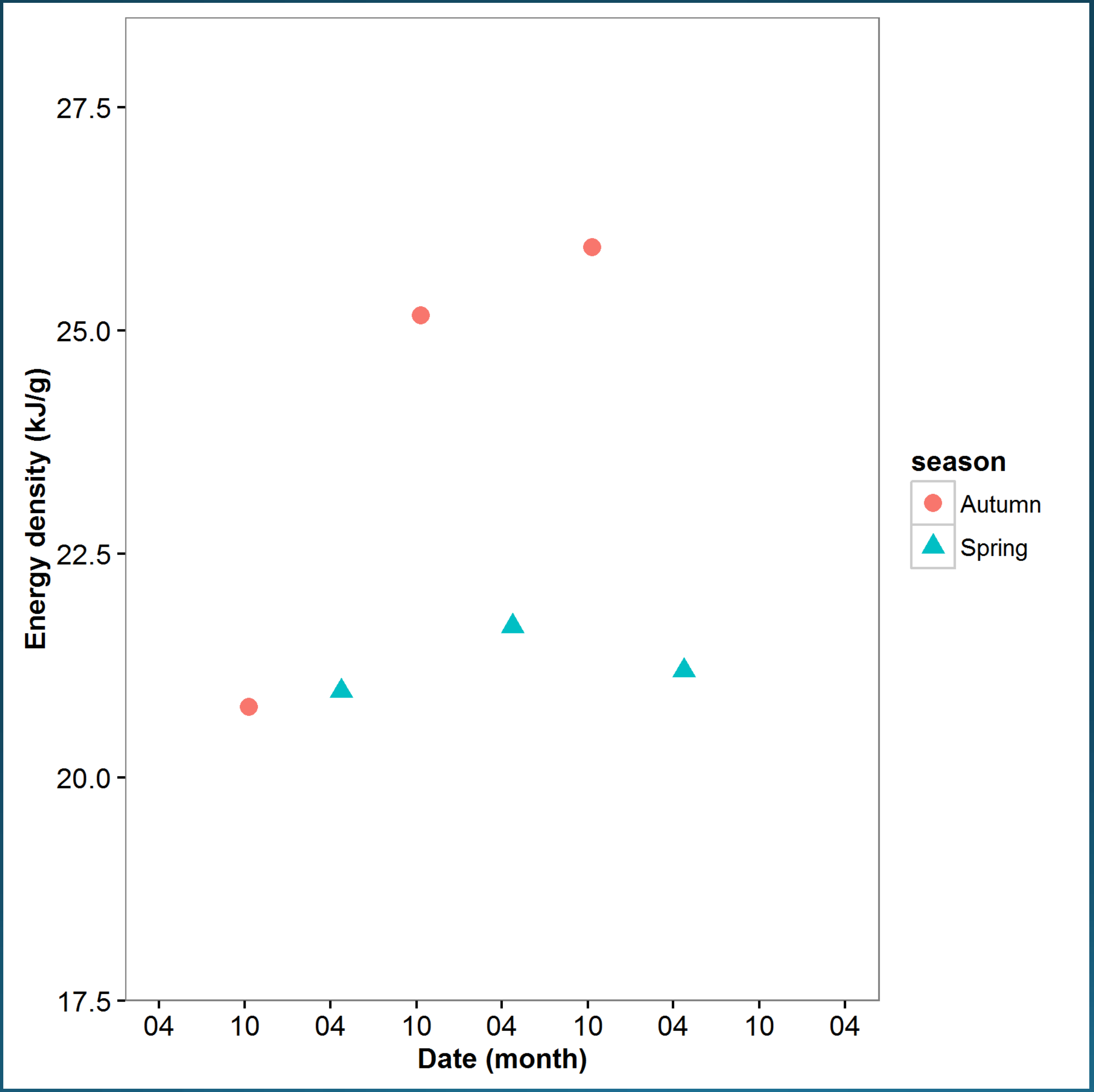

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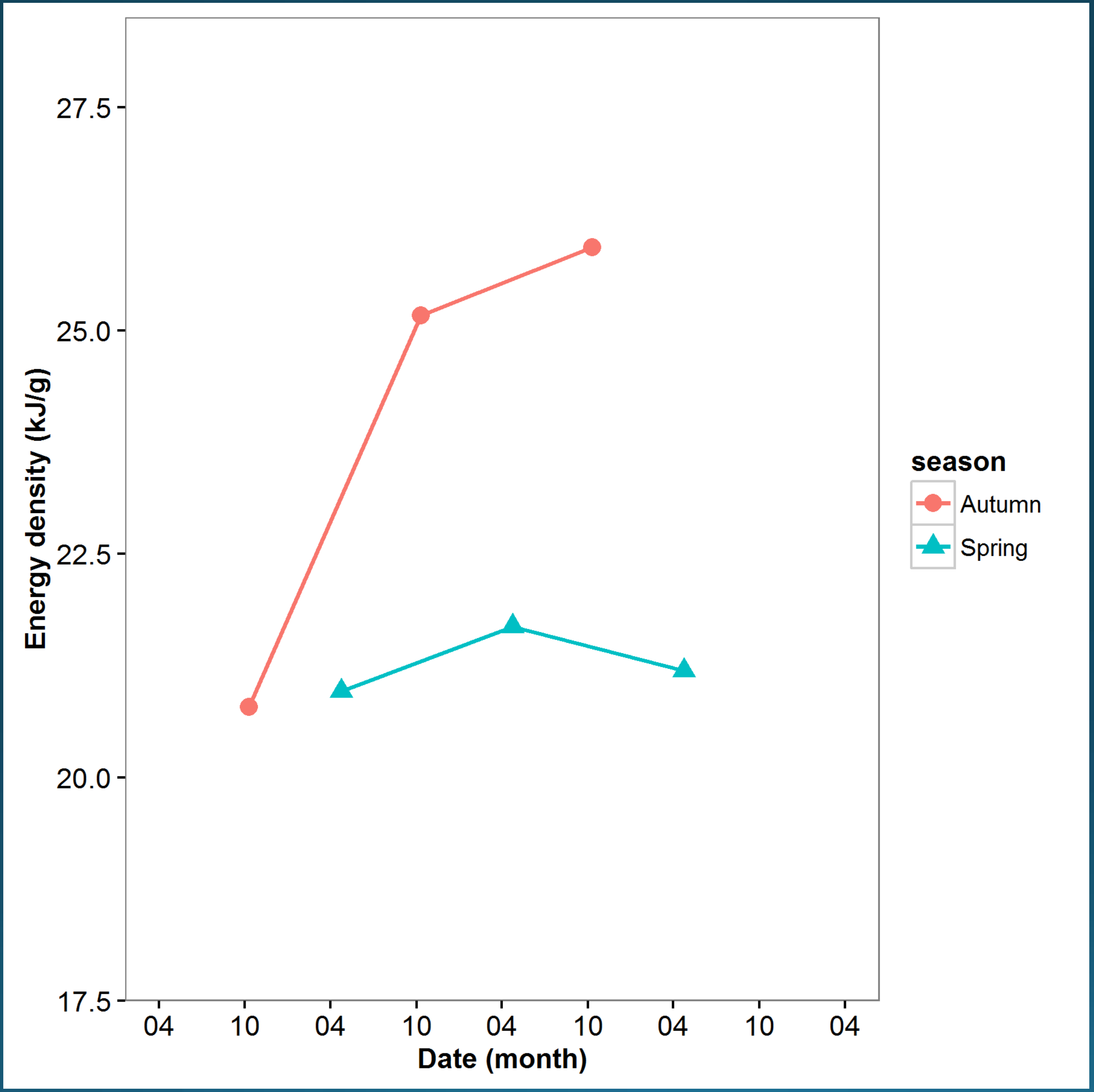

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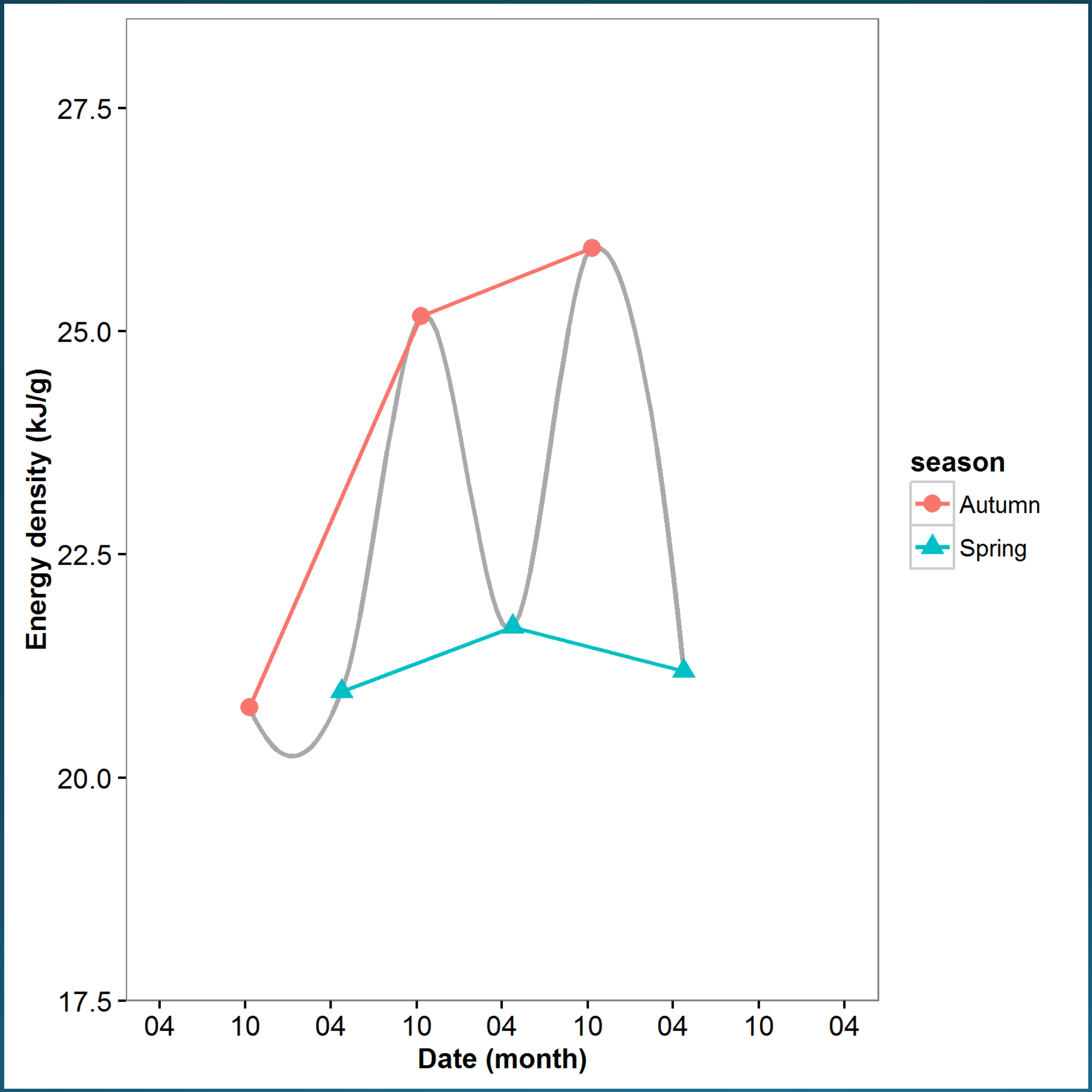
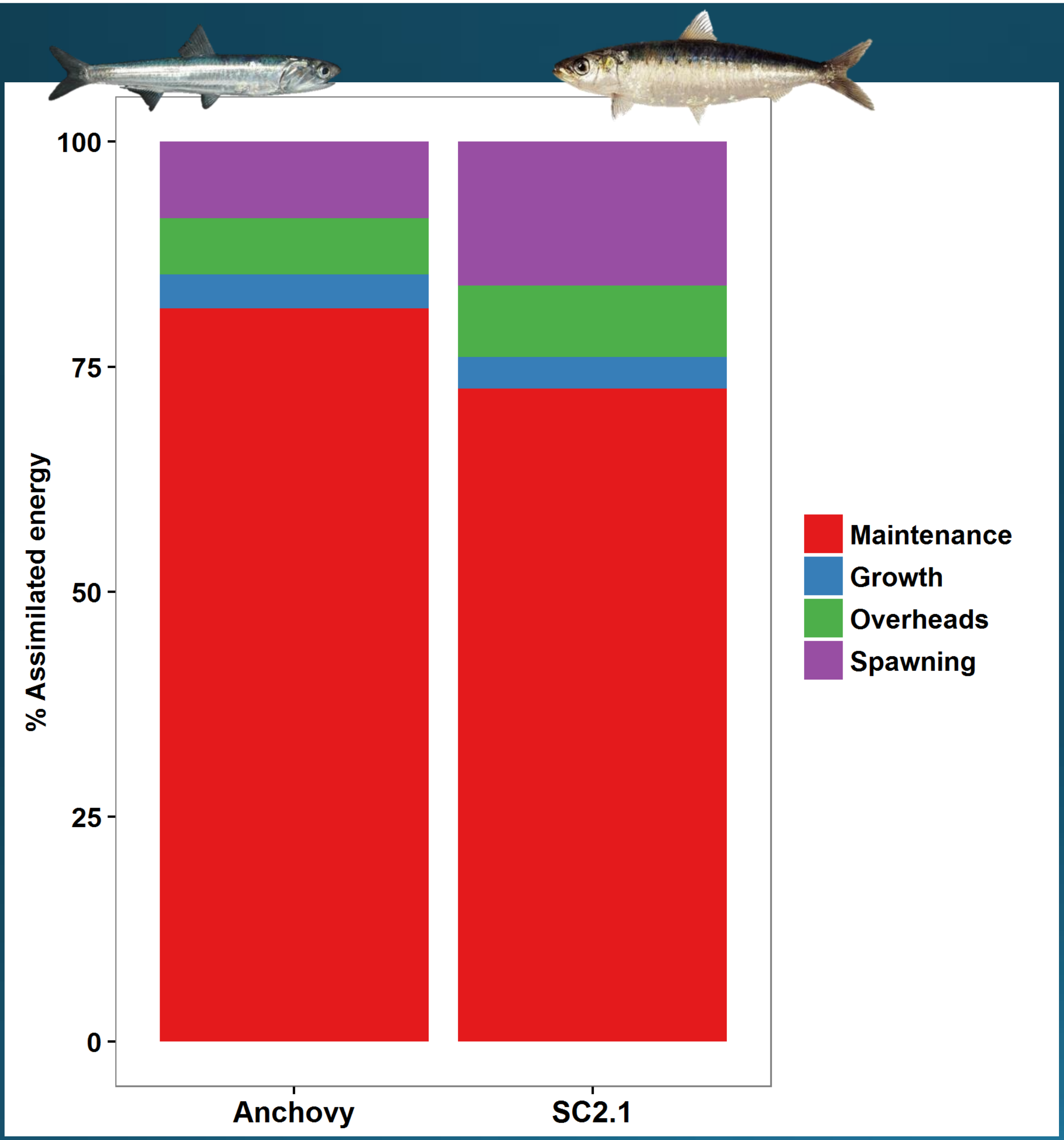


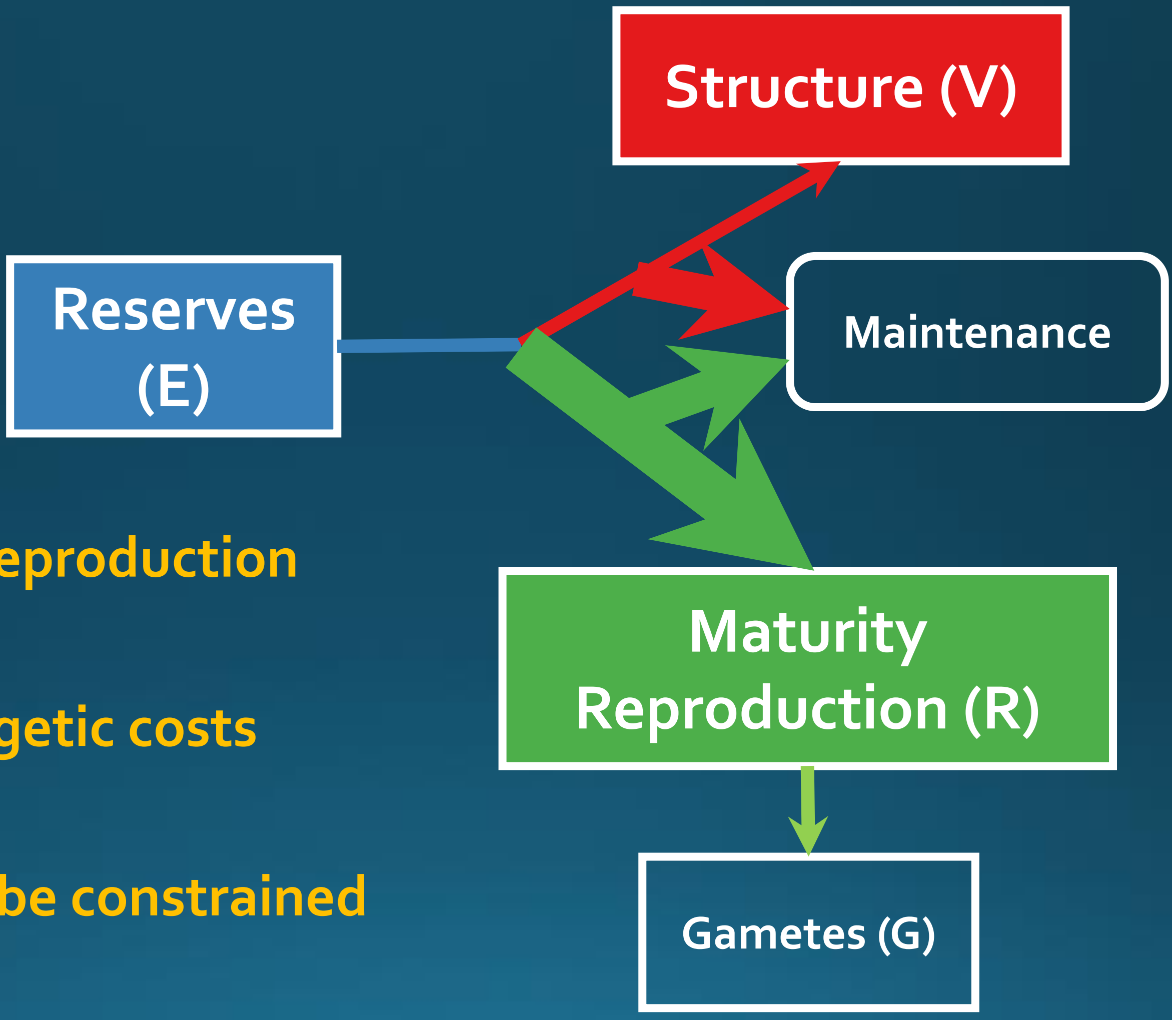
5. Energetic expenses & DEB constraints



Maintenance & Reproduction

→ largest energetic costs

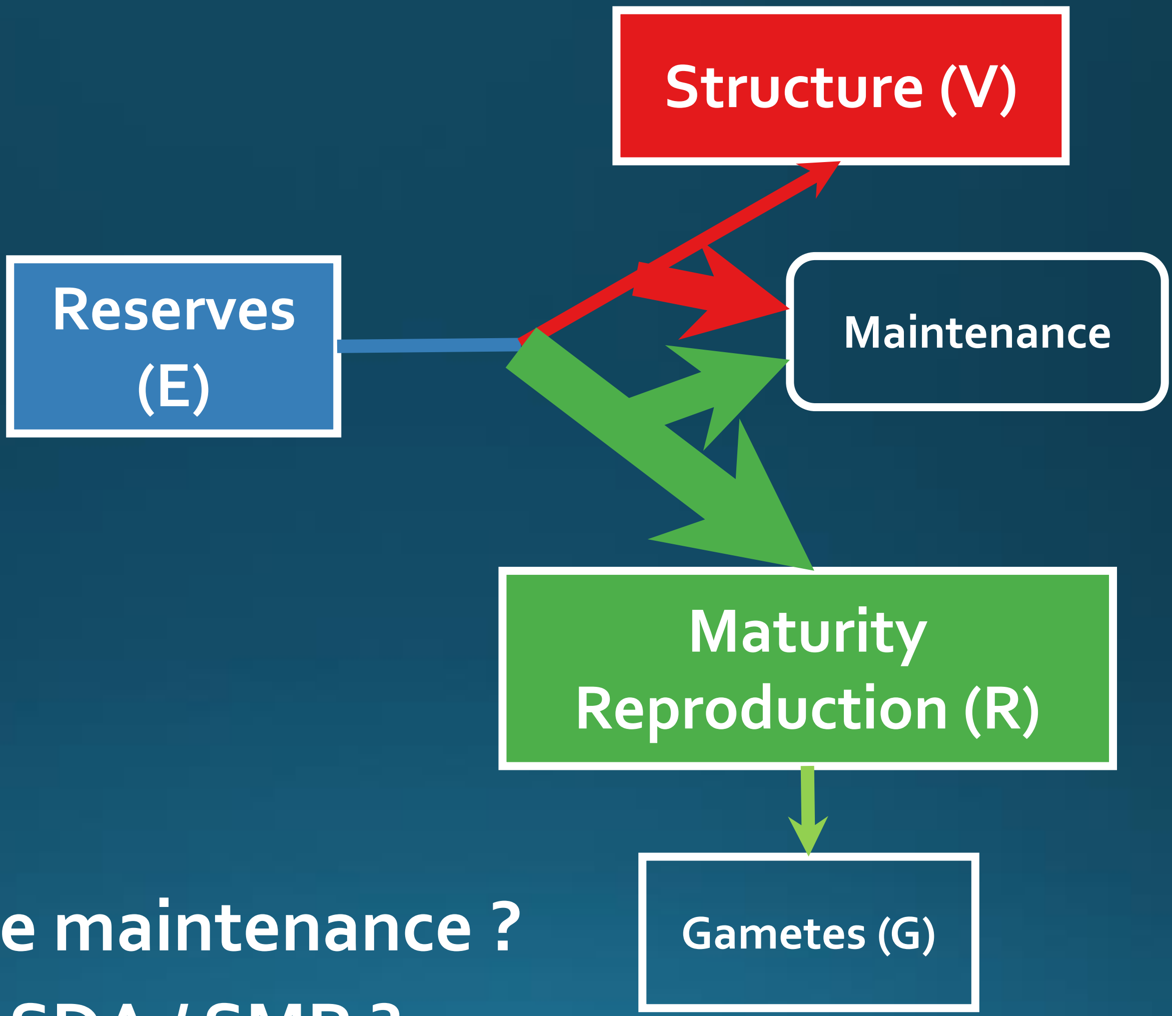
5. Energetic expenses & DEB constraints



Maintenance & Reproduction

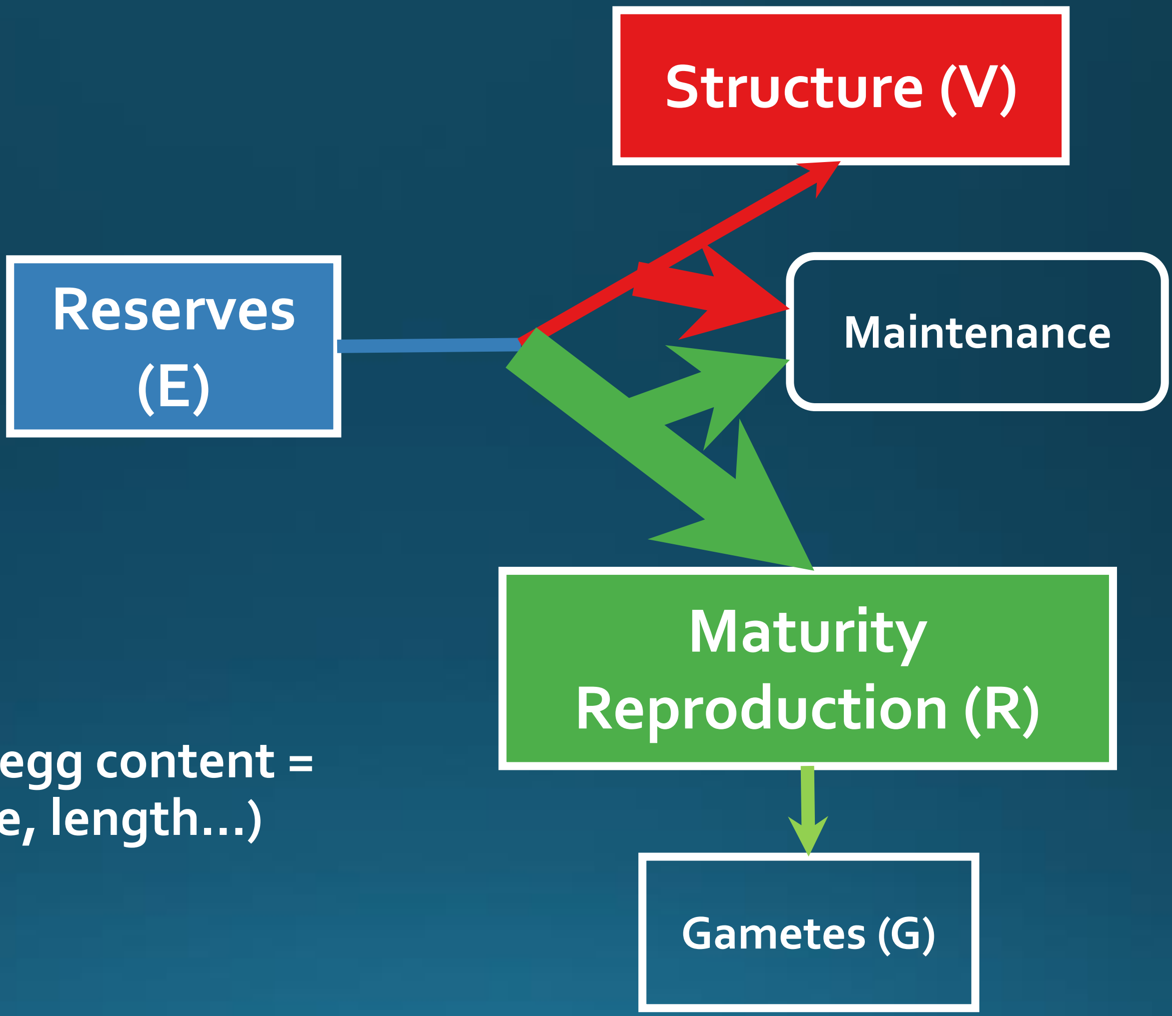
→ Largest energetic costs

→ Largest fluxes to be constrained



How do we measure maintenance ?

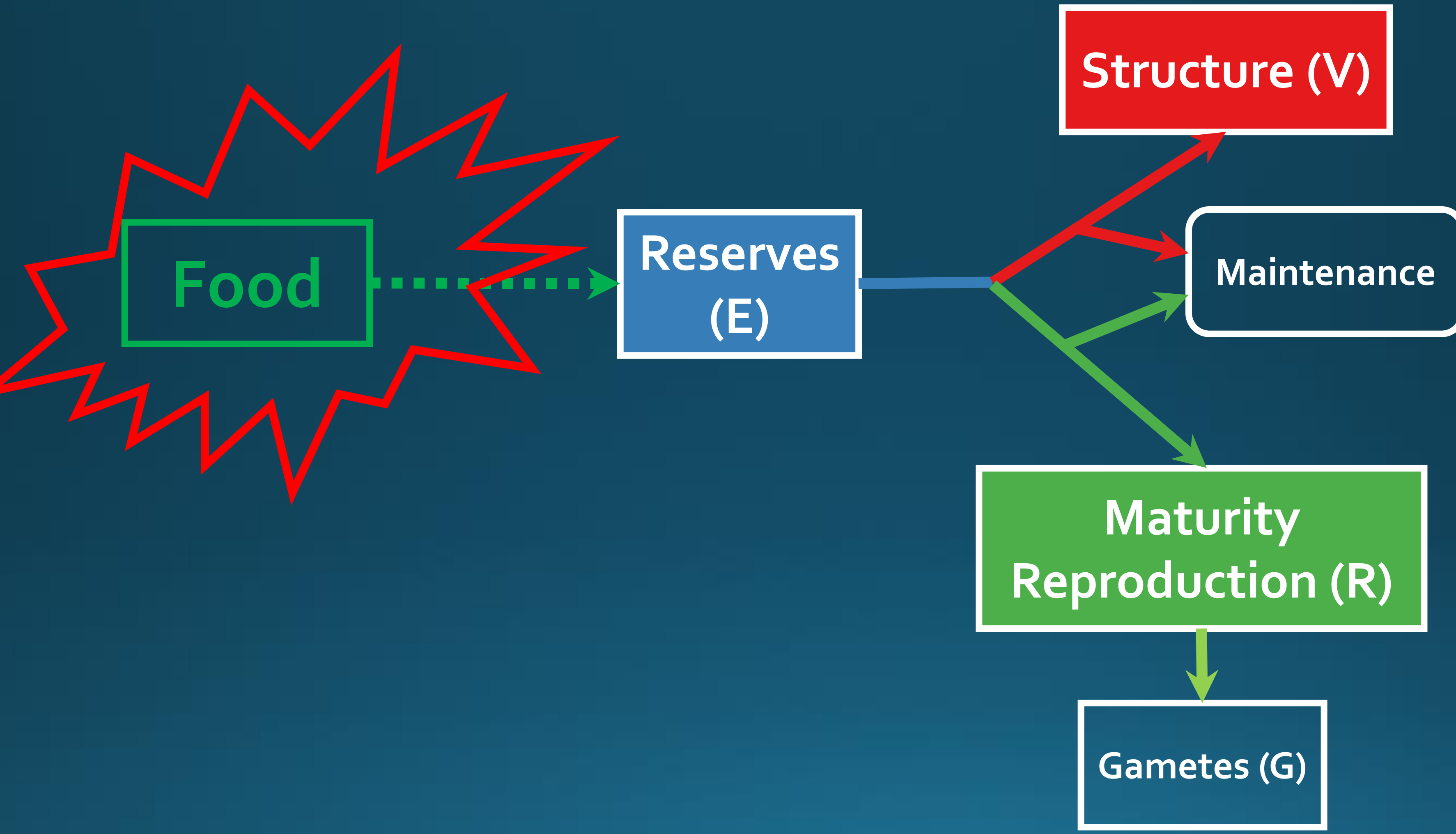
Respirometer ? SDA / SMR ?



Spawning

→ fecundity, frequency, egg content = f(condition, season, age, length…)

6. Energy inputs ?



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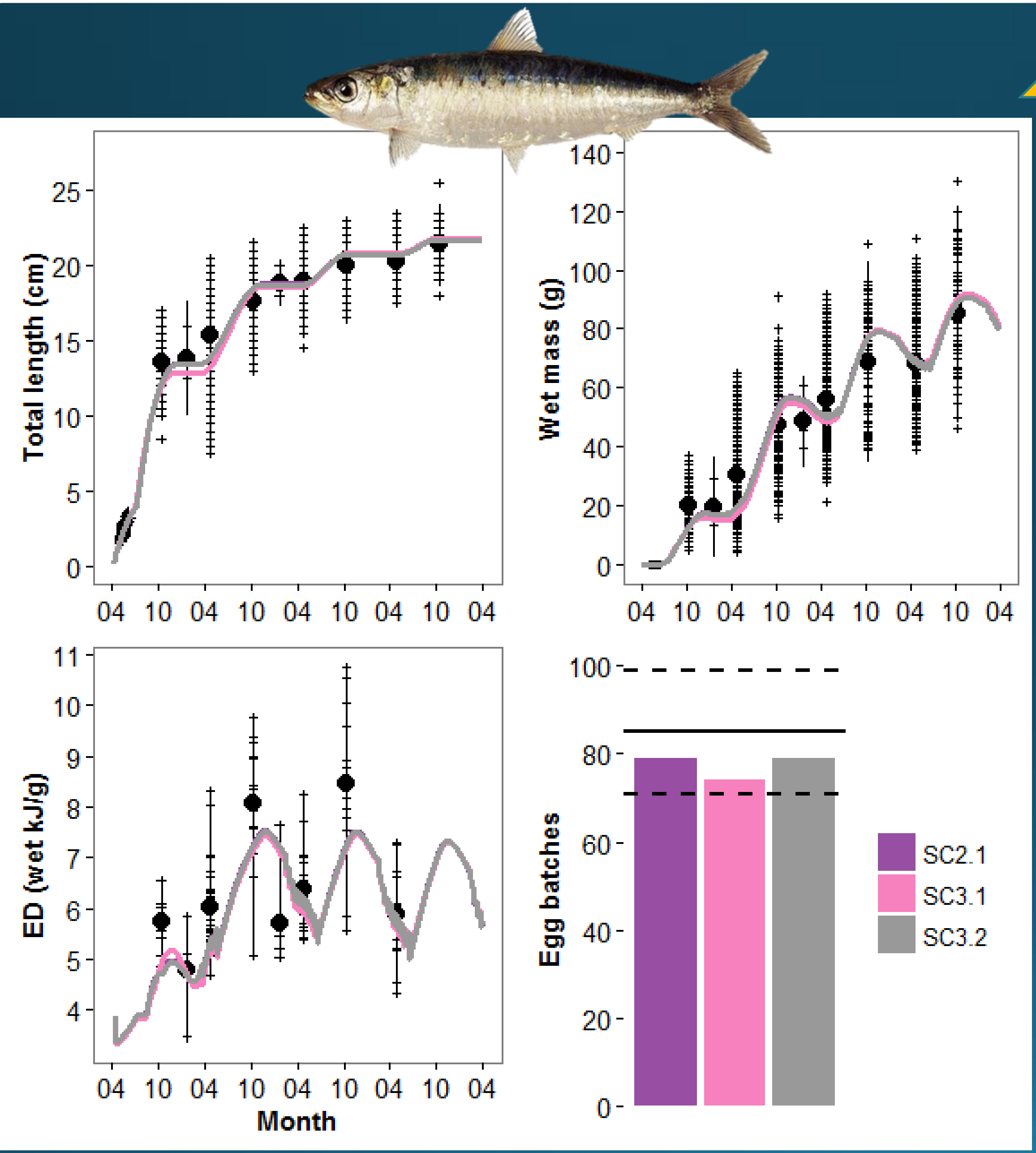

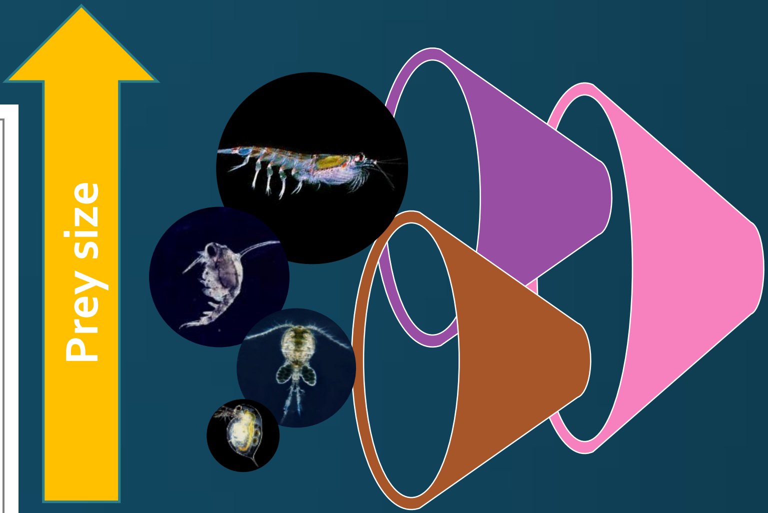

SC3 : Size, Spawning & Feeding

SC2.1 : anchovy (large preys)

SC3.1 : sardine (small preys)

SC3.2 : hybrid (small & large)

Daily consumption rate ~1-4%

Energy content of the food is needed

Hartman and Brandt 1995, **Estimating Energy Density of Fish**

"Despite the widespread use of bioenergetics models in fisheries, **information on one key input variable, energy density (J/g) of predators and prey, has been limited**."

"If results obtained from the use of bioenergetics models are to be accurate, **estimates of energy density of predators and prey are required for specific seasons, fish ages**, and ecosystems."

What data do we need ?

To properly calibrate a DEB model

1. Length & weight data (are not enough)
2. Energy content / proximate composition
3. Energetic cost of spawning
4. Energetic cost of maintenance
5. Energetic input from the food

… following the appropriate schedule of each variable…

For more information

Gatti et al. 2017, Comparing biological traits of anchovy and sardine in the Bay of Biscay: a modelling approach with the Dynamic Energy Budget.

To properly calibrate a DEB model

1. Length & weight data (are not enough)
2. Energy content / proximate composition
3. Energetic cost of spawning
4. Energetic cost of maintenance
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… following the appropriate schedule of each variable…

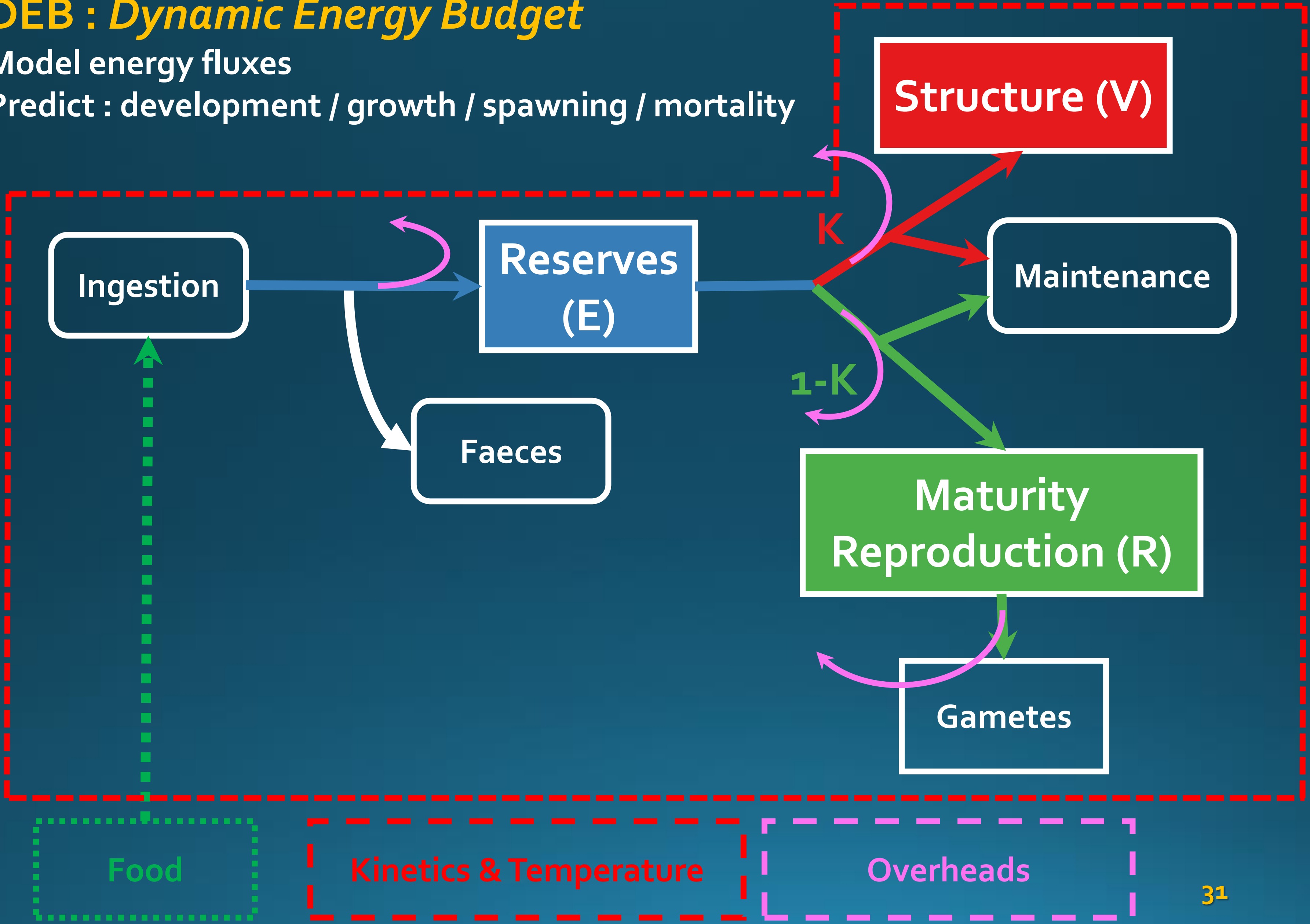
We probably need all these data for all bioenergetics models (not only for the DEB…)

Thank you !

DEB : *Dynamic Energy Budget*

Model energy fluxes

Predict : development / growth / spawning / mortality

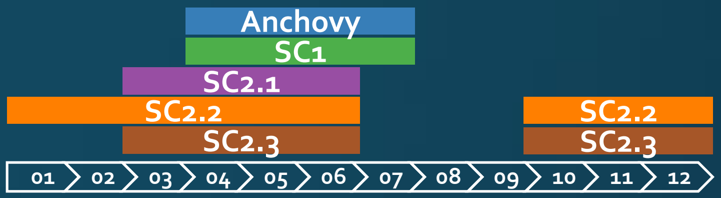


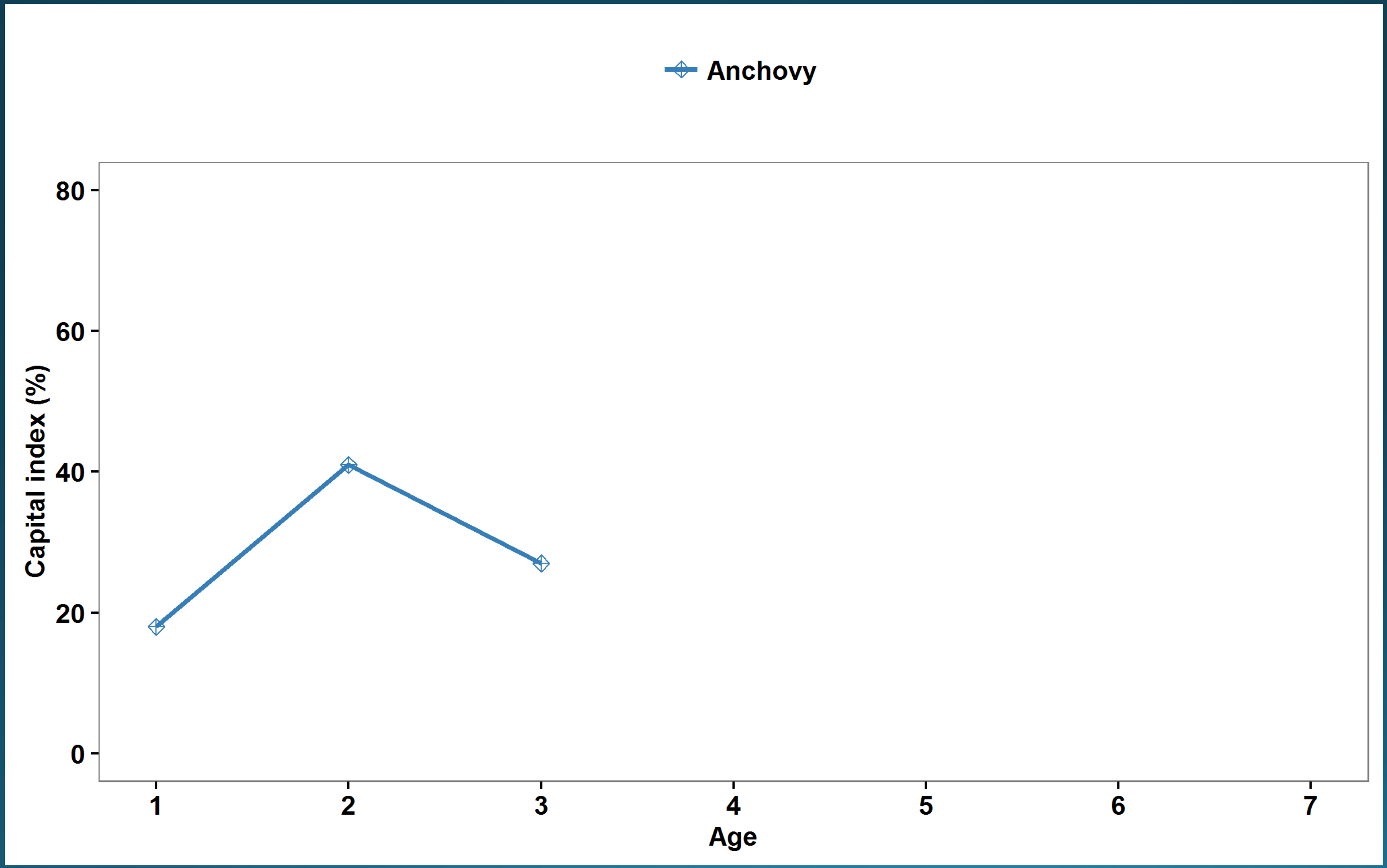
4. Which time scale ?

Indeterminate spawning: « Capital » & « Income »

- **Anchovy ~ « Income spawner »**

  Somarakis et al. 2004





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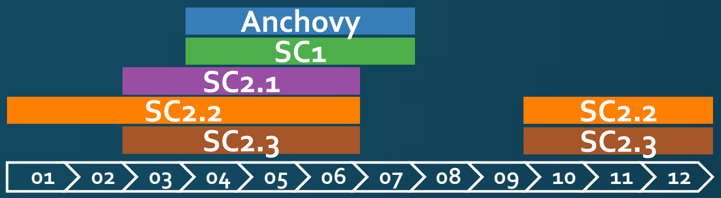

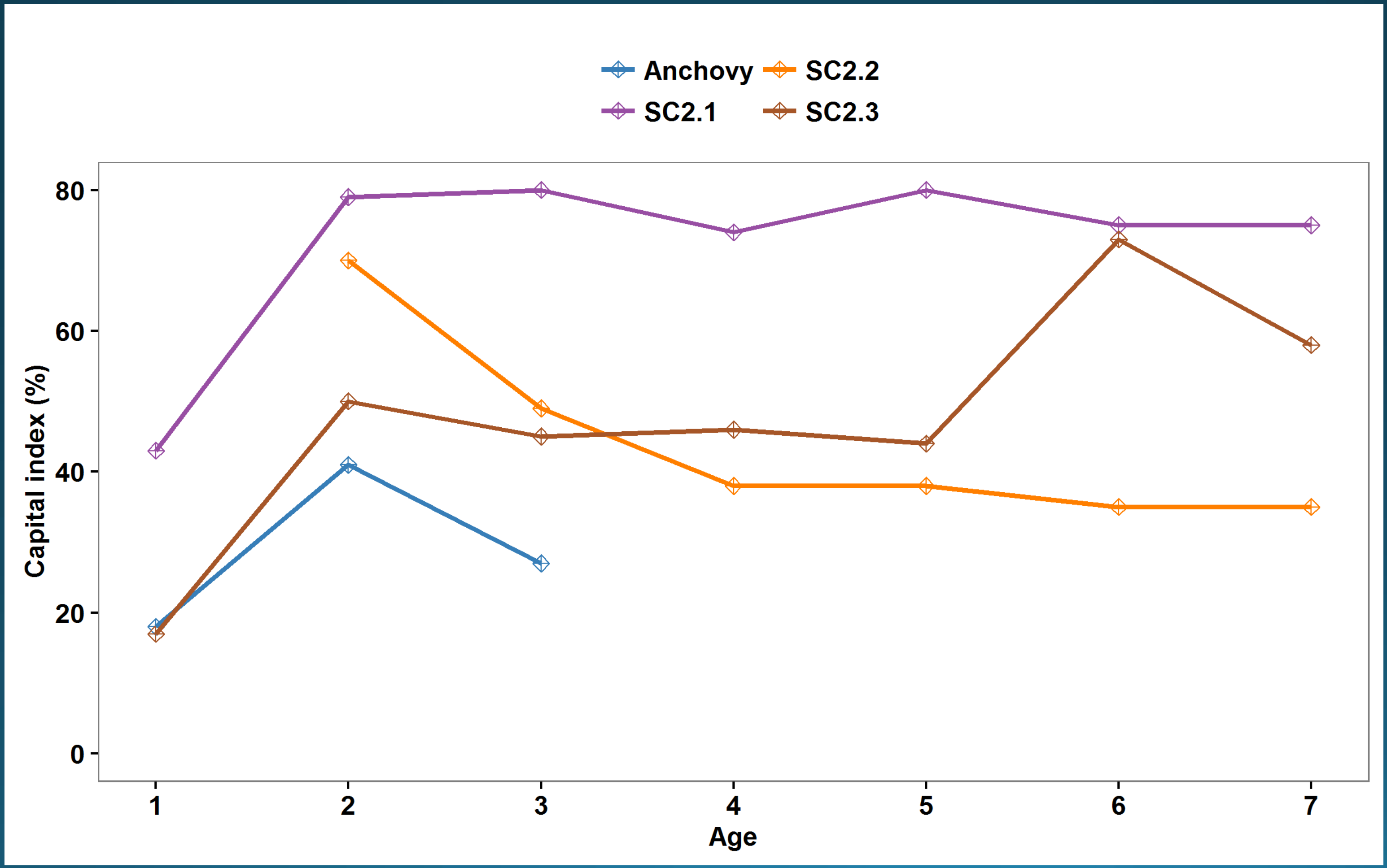

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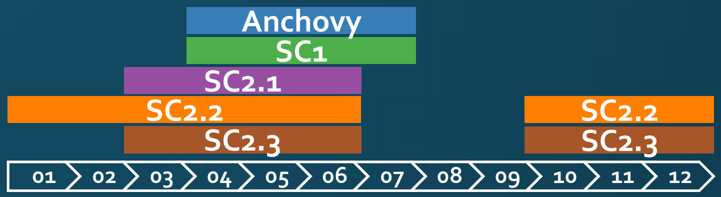

- « Income / Capital » : « match / mismatch »

  Reproduction / bloom zooplankton

Somarakis et al. 2004, Ganias et al. 2007 & Mc Brides et al. 2015