

Proximate composition and water to derive condition states and energy density of small pelagic fish

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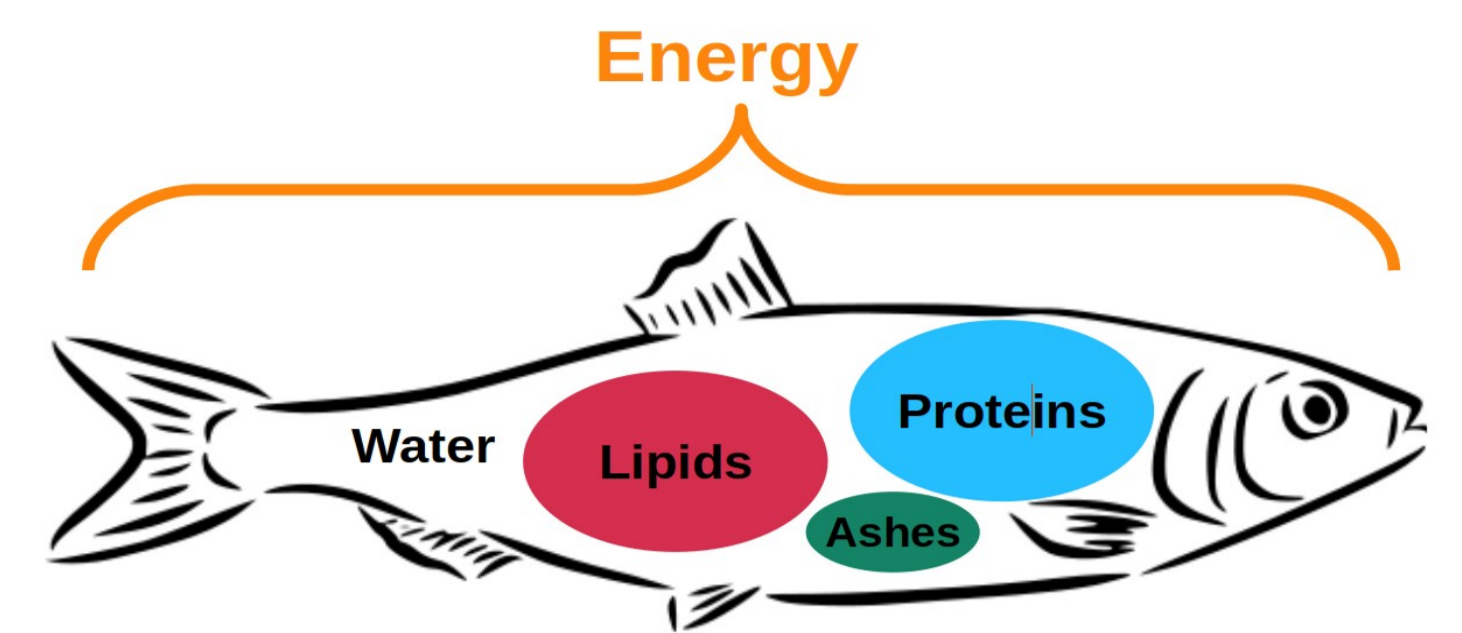


Introduction

- Decrease in **body condition** (via morphometric indices) in **sardine** and **anchovy** ^{1,2}
- But the **reliability** of morphometric indices is debated ³
- **Energy content** is a **reliable** indicator of the condition of individuals, populations, and ecosystems ⁴
- But directly measuring **energy content** is time-consuming and costly
- **Energy density** is linked to **proximate composition** (**lipids**, **proteins**, **ash**, **water**) in fish.

Objectives

- 1 Study the **relationships** between **proximate composition**, **energy density**, and the **physiological state** of fish
- 2 Compare **four methods** to rapidly and accurately estimate **energy density**



Material & Methods

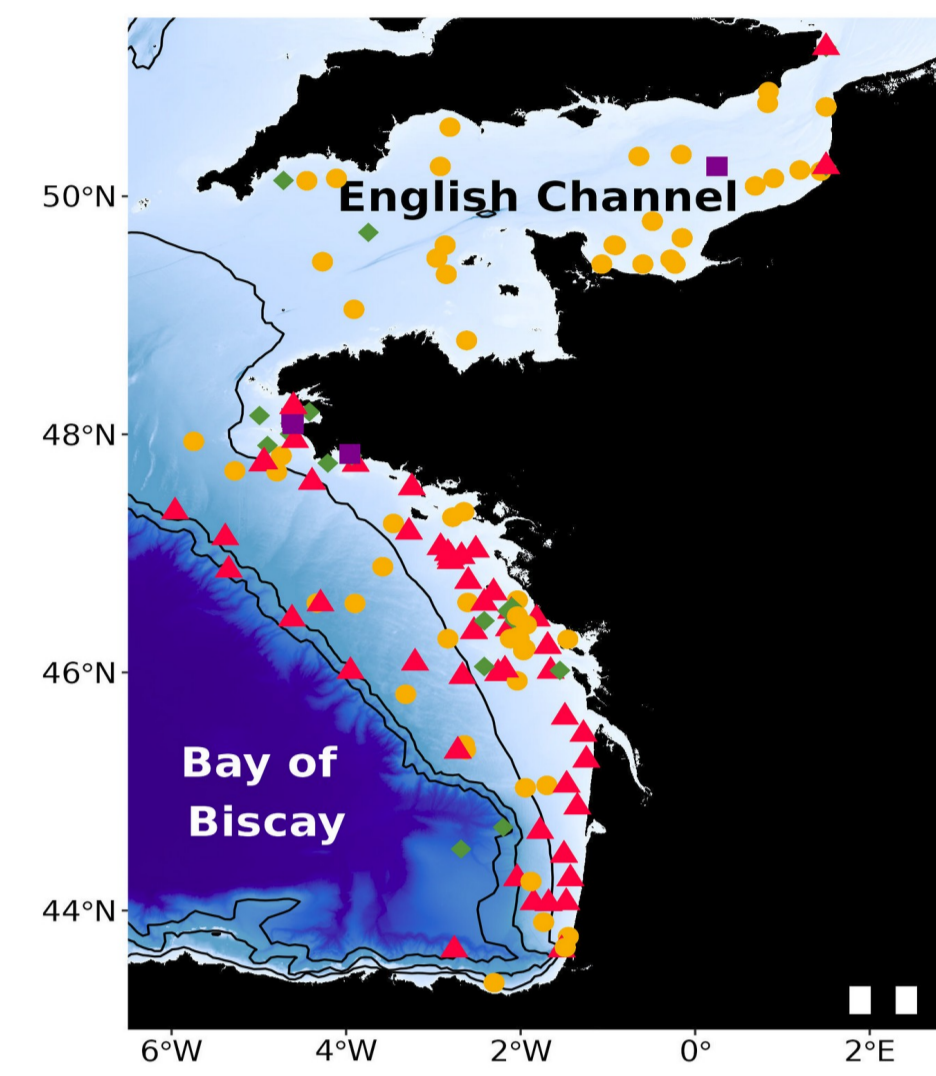
Data

- **Energy density** using bomb calorimetry
- Proximate composition (**lipids**, **proteins**, **ashes**)

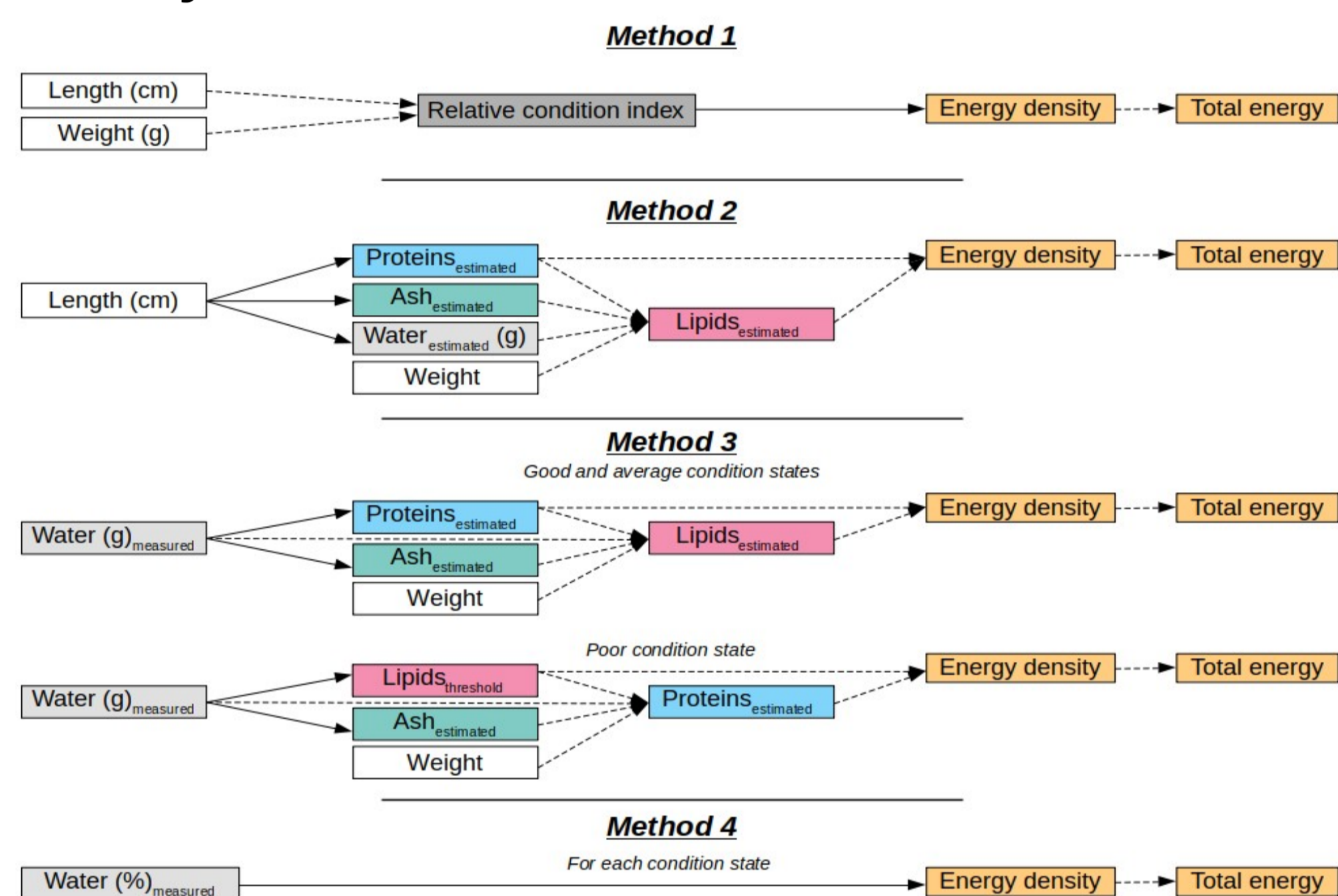
Considered species

- Sardine (*Sardina pilchardus*)
- Anchovy (*Engraulis encrasicolus*)

	Energy density	Proximate composition
Sardine	976	116
Anchovy	503	104
Total	1479	220



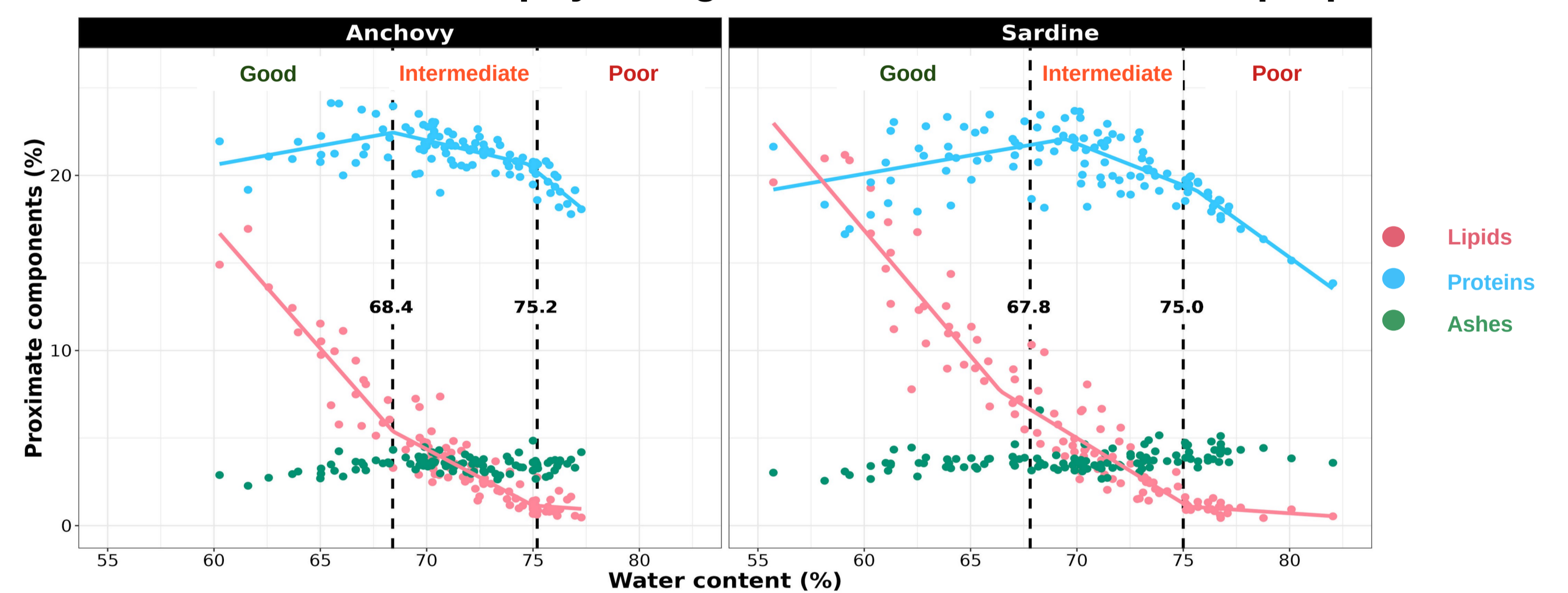
Energy density estimation



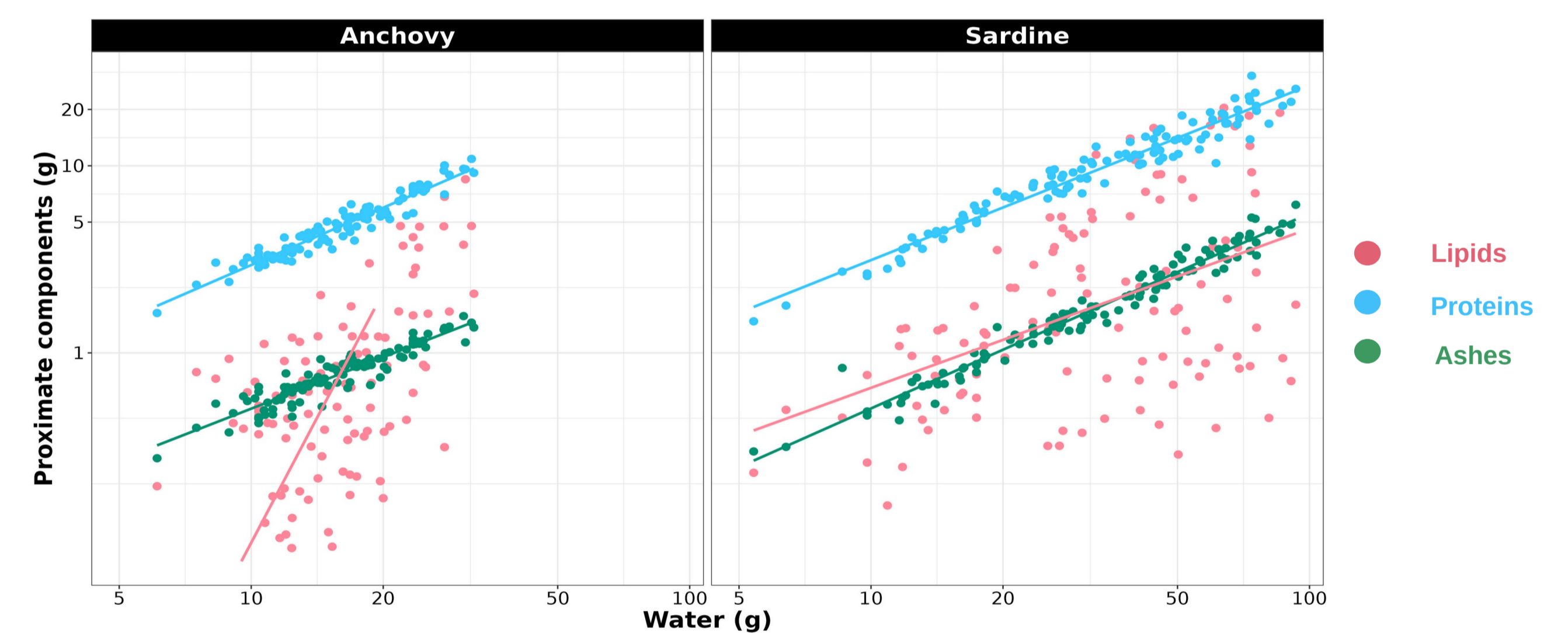
Results

1 Relationship between proximate composition, water, and physiological state

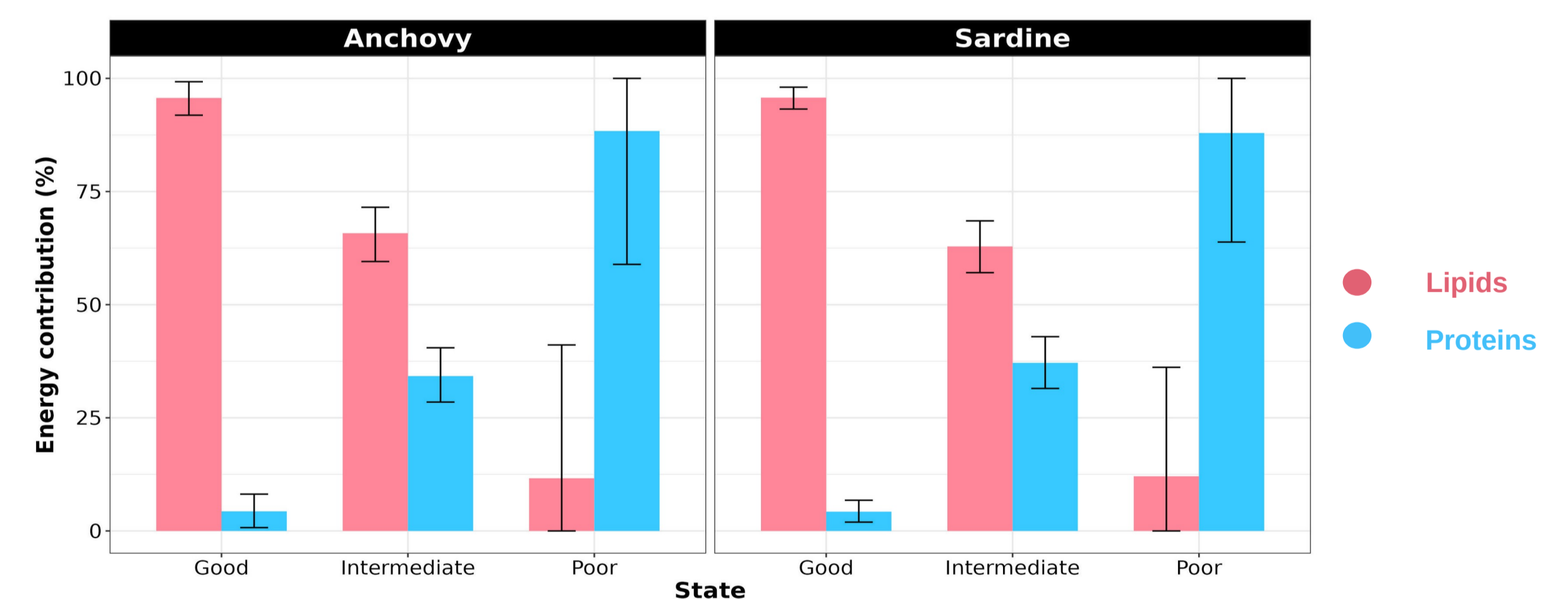
1.1. Identification of three physiological states based on water proportion



1.2. Water mass is highly correlated with protein and ash masses, but not lipid mass



1.3. Lipids are the main contributors to energy, but proteins can contribute when lipids are depleted



Discussion & Conclusion

1 What are the relationships between proximate composition, water, and energy ?

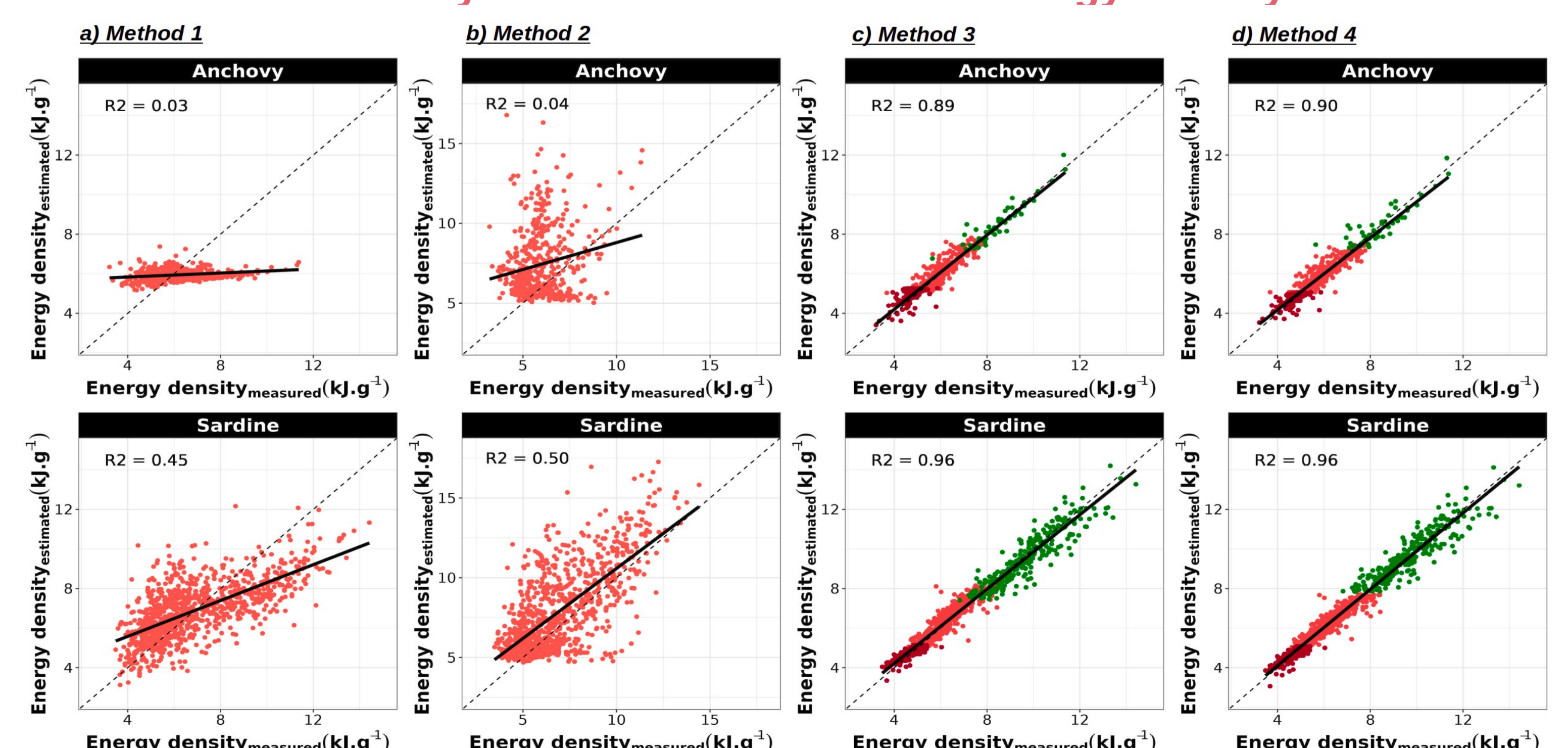
- Identification of three similar condition states in both species based on water proportion
- Strong relationships between water mass and protein and ash masses, but not with lipid mass
- Lipids are the primary energy source, with proteins used in extreme conditions

2 What is the best method to estimate energy density ?

- Size and weight do not allow accurate estimation of energy density
- Water content is an accurate indicator of energy density
- Long-term implementation of water measurements during the PELGAS survey

Measuring water content could provide key information for assessing the condition of individuals, populations and ecosystems

2 Comparison of the four methods for estimating energy density: Water content is by far the best indicator of energy density



For methods 3 et 4 : ● Good ● Intermediate ● Poor

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References

1. Véron et al., 2020. Major changes in sardine growth and body condition in the Bay of Biscay between 2003 and 2016. *Progr. Oceanogr.*
2. Taboada et al., 2024. Shrinking body size of European anchovy in the Bay of Biscay. *Global Change Biology.*
3. Labocha et al., 2014. Which body condition index is best? *Oikos.*
4. Spitz and Jouma'a, 2013. Variability in energy density of forage fishes from the Bay of Biscay. *J. Fish Biol.*

Linked articles

- Favreau et al., 2025. Condition states in anchovy (*Engraulis encrasicolus*) and sardine (*Sardina pilchardus*) revealed by energy and proximate composition analysis. *J. Fish Biol.*
- Favreau et al., 2025. Assessment of energy indices for exploited small pelagic fish. *Aquatic Living Resources.*
- Favreau et al., 2025. Seasonal and Inter-annual dynamics in the energy seascapes of a marine top predator. *Royal Society Open Sci.*