Ecosystem functioning shifts in the Mediterranean Sea using trawling surveys

WP3 Biodiversity status and cumulative impacts

Task 3.3. Establish links to ecosystem functions and their associated services

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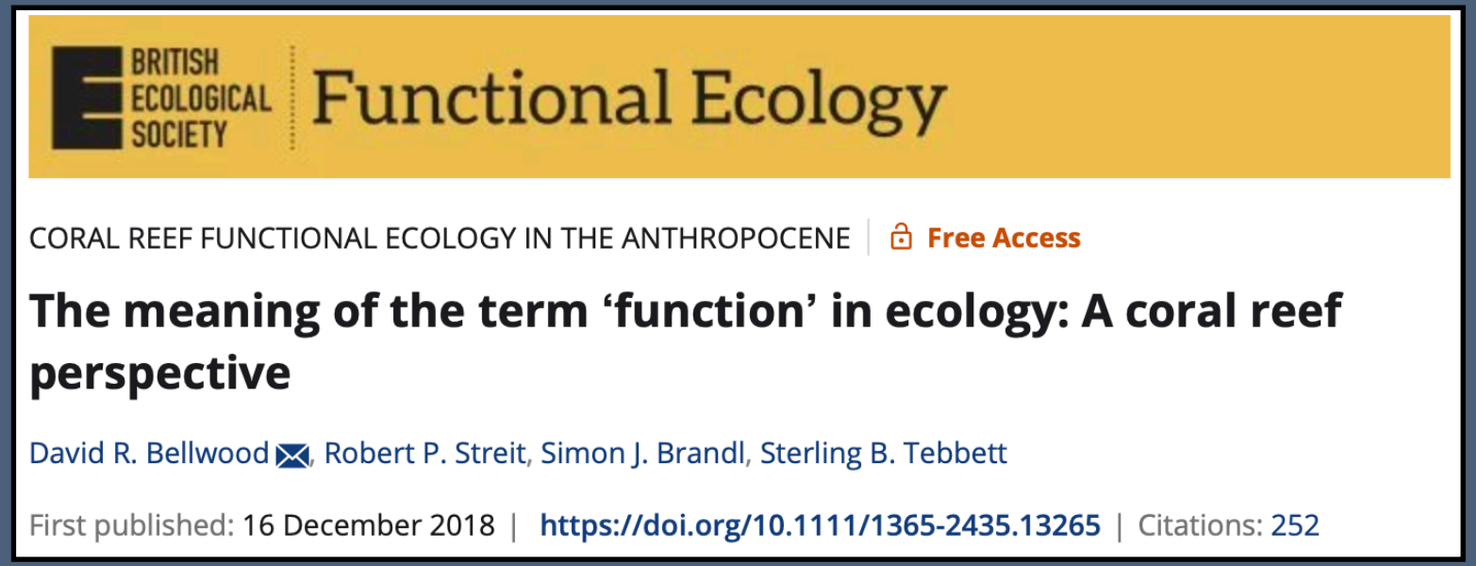
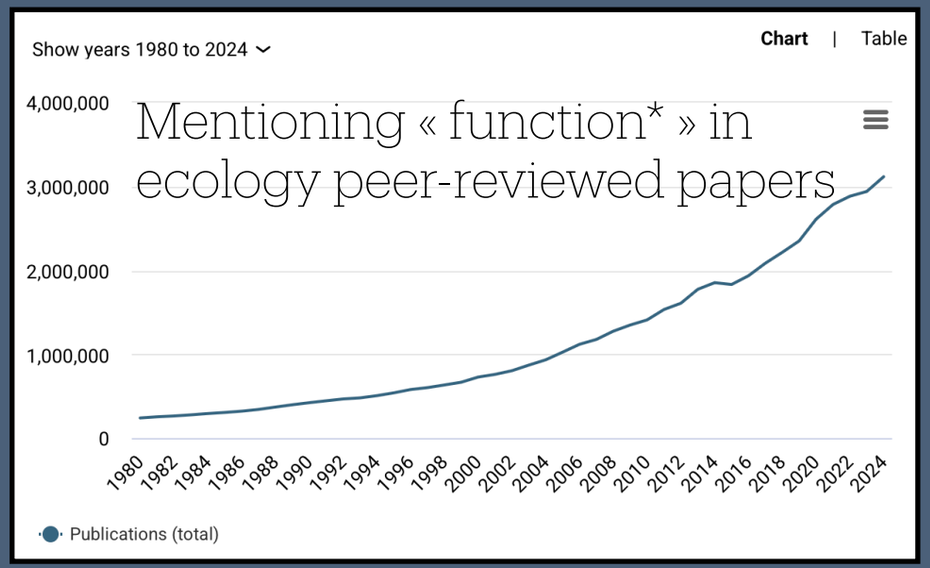
What are we talking about with ‘functioning’?

Function is now a ‘fancy’ word, which is used for a bit everything





In the context of this study, we’ll use the definition from Jax (2005)

> “Function refers to the flow of energy or material within an ecosystem, and therefore, functioning of a complex system of interactions can be defined as the sum of processes or functions that sustain the system”

Keeping in mind that a function is defined as a flow of energy within an ecosystem, we base our approach on Schiettekatte *et al.*, 2018, 2021

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RESEARCH ARTICLE | Free Access

Nutrient limitation, bioenergetics and stoichiometry: A new model to predict elemental fluxes mediated by fishes

Nina M. D. Schiettekatte, Diego R. Barneche, Sébastien Villéger, Jacob E. Allgeier, Deron E. Burkepile, Simon J. Brandl, Jordan M. Casey, Alexandre Mercière, Katrina S. Munsterman ... See all authors

First published: 23 June 2020 | https://doi.org/10.1111/1365-2435.13618 | Citations: 30

R Package to define
Fish functioning
Fish + Fluxes = Fishflux

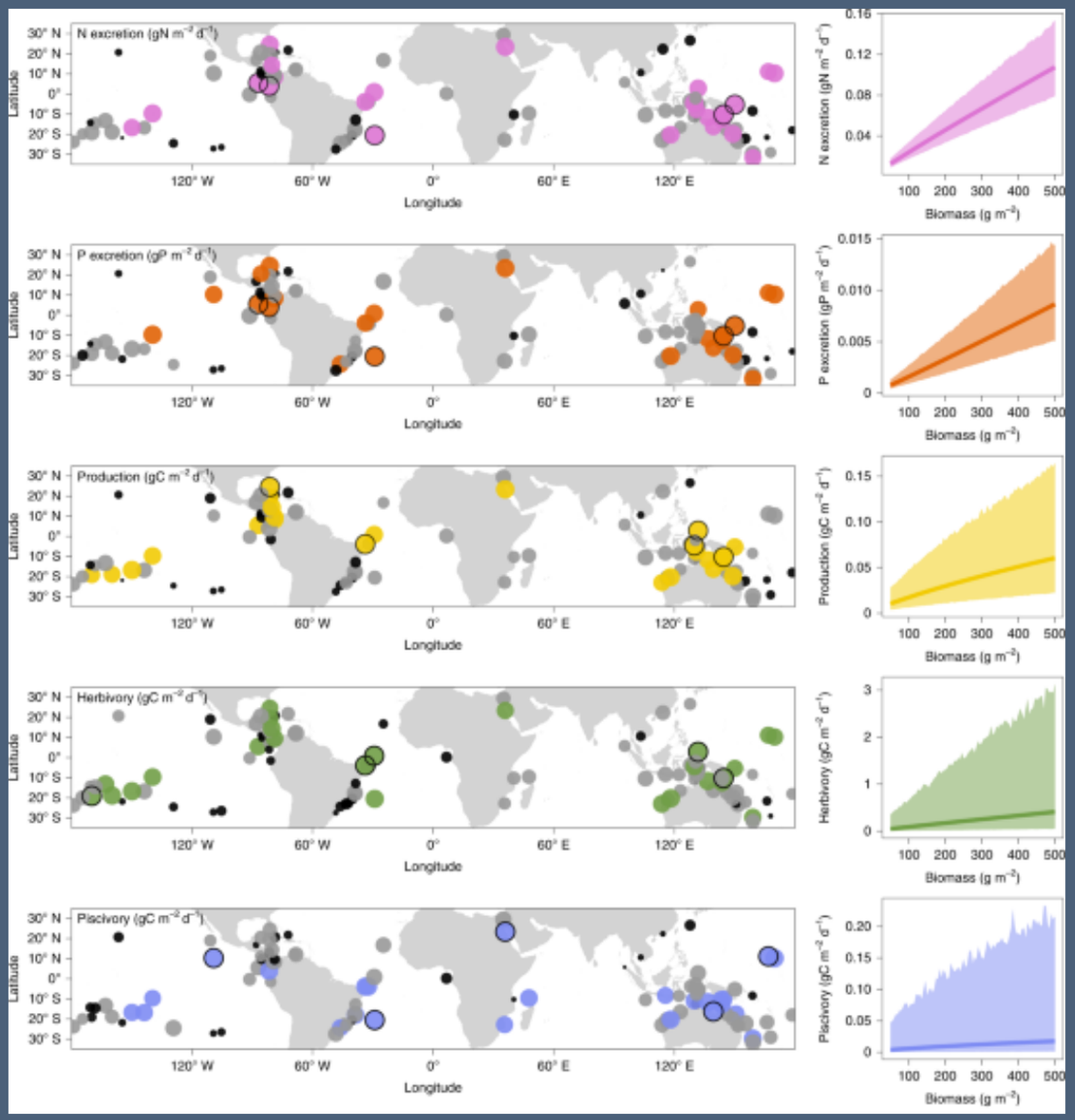
Based on the Metabolic Theory of Ecology (MTE) *i.e.*, we have to define fish metabolic rates such as Standard and Maximum Metabolic Rate (SMR & MMR) to quantify the fluxes

Fish + Fluxes = Fishflux

Biological trade-offs underpin coral reef ecosystem functioning

Nina M. D. Schiettekatte ✉, Simon J. Brandl, Jordan M. Casey, Nicholas A. J. Graham, Diego R. Barneche, Deron E. Burkepile, Jacob E. Allgeier, Jesús E. Arias-Gonzaléz, Graham J. Edgar, Carlos E. L. Ferreira, Sergio R. Floeter, Alan M. Friedlander, Alison L. Green, Michel Kulbicki, Yves Letourneur, Osmar J. Luiz, Alexandre Mercière, Fabien Morat, Katrina S. Munsterman, Enrico L. Rezende, Fabian A. Rodríguez-Zaragoza, Rick D. Stuart-Smith, Laurent Vigliola, Sébastien Villéger & Valeriano Parravicini

Nature Ecology & Evolution **6**, 701–708 (2022) | Cite this article



In Schiettekatte *et al.*, 2021, they defined the functioning of reef fish communities worldwide with a combination of 5 functions

- Nitrogen excretion
- Phosphorus excretion
- Growth
- Herbivory consumption (Primary Consumers)
- Piscivory consumption (Secondary Consumers)

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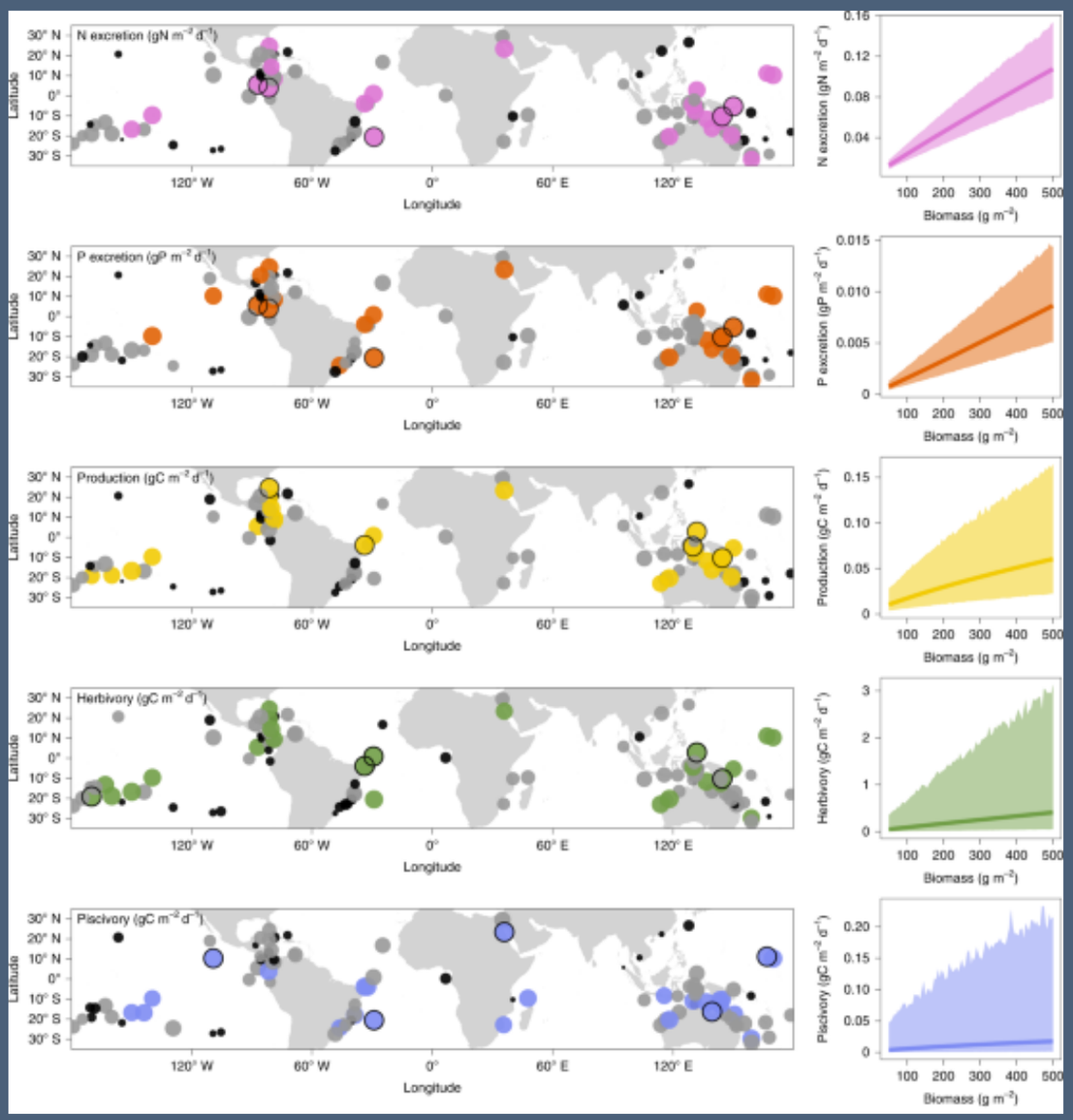

They showed that no site maximized all functions simultaneously—there was always a trade-off.

What's interesting for us is that they did not have time series data, so they couldn't observe how functioning changed over time.

They were also unable to contrast it with global change for the same reason.

Finally we can also add the scavenger consumption as it might be an important function for the B-Useful project

Fish + Fluxes = Fishflux

Symbol	Description	Unit
a_k	Element-specific assimilation efficiency	–
l_t	Total length of individual	cm
linf	Asymptotic adult length (VBGC)	cm
κ	Growth rate parameter (VBGC)	yr^{-1}
t_0	Age at settlement (VBGC)	yr
lw_a	Parameter length-weight relationship	$g\ cm^{-1}$
lw_b	Parameter length-weight relationship	–
Q_k	Element-specific body content percentage	%
f_0	Metabolic normalisation constant independent of body mass	$g\ Cg^{-a}d^{-1}$
alpha	Mass-scaling exponent	–
theta	Activity scope	–
v	Environmental temperature	C
h	trophic level	–
r	Aspect ratio of caudal fin	–
F0nz	Mass-specific turnover rate of N	$g\ Ng^{-1}d^{-1}$
F0pz	Mass-specific turnover rate of P	$g\ Pg^{-1}d^{-1}$
mdw	Ratio of dry mass and wet mass of fish	–
D_k	Elemental stoichiometry of diet	%

. Overview of inputs, including input parameters, to be specified by the user of the model. k indicates c, n or p. VBGC = von Bertalanffy growth curve.

But there is a ton of parameters to define before using FishFlux

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Trophic parameters

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- Trophic parameters
- Growth parameters
- Metabolic parameters

Fish + Fluxes = Fishflux

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- Morphologic parameters

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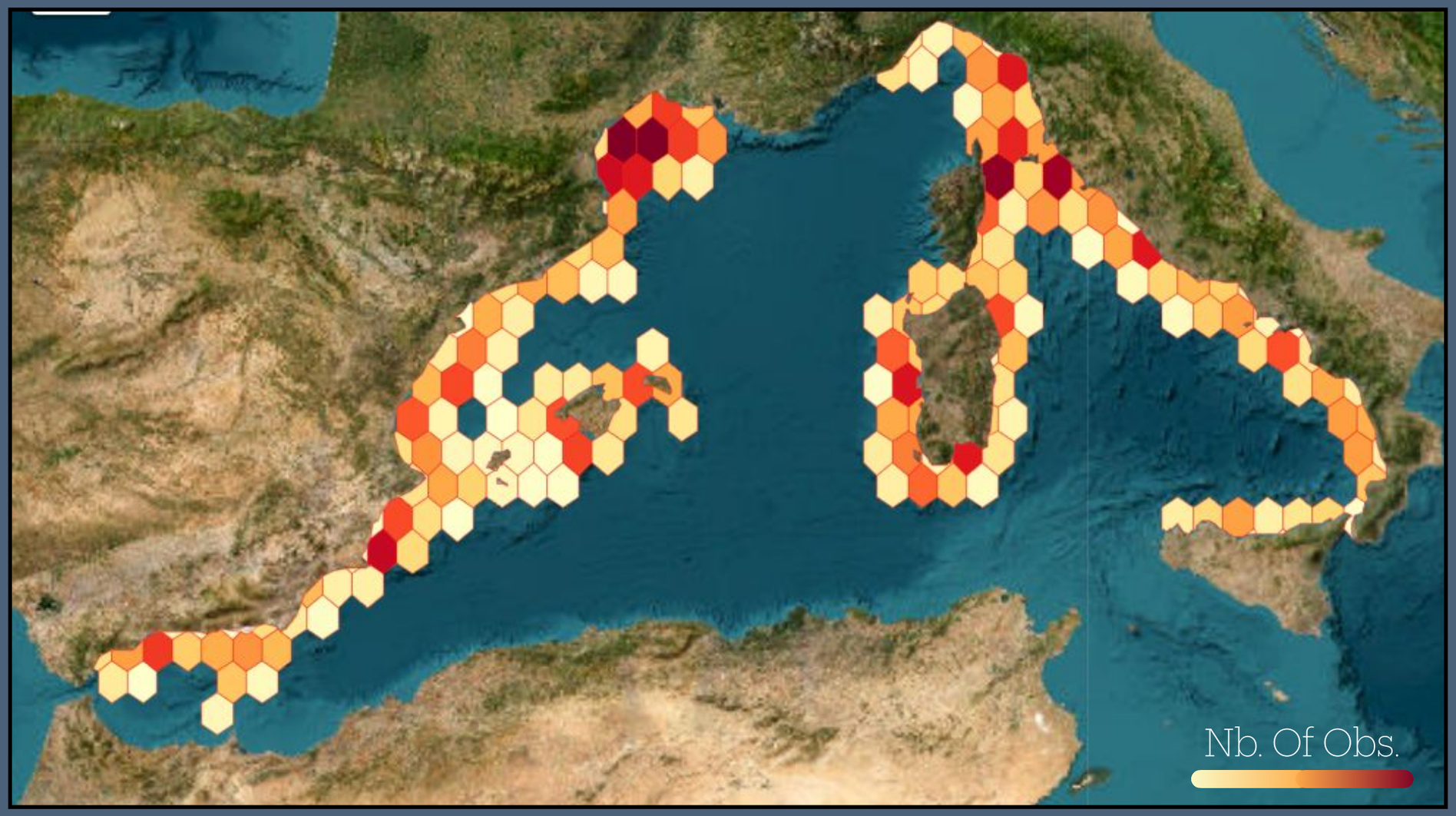
But there is a ton of parameters to define before using FishFlux

- Survey parameters (data)
- Trophic parameters
- Growth parameters
- Metabolic parameters
- Morphologic parameters
- Constant

The most difficult to get would be the metabolic and the trophic ones

What has been done so far?

We initially focus on the Western Mediterranean Sea before expanding our spatial scope to the entire Mediterranean basin (and the Atlantic?).



361 fish out of 1246 species in total

Temporal resolution: 1999–2021 | Spatial resolution: 0.5° hexagonal grid

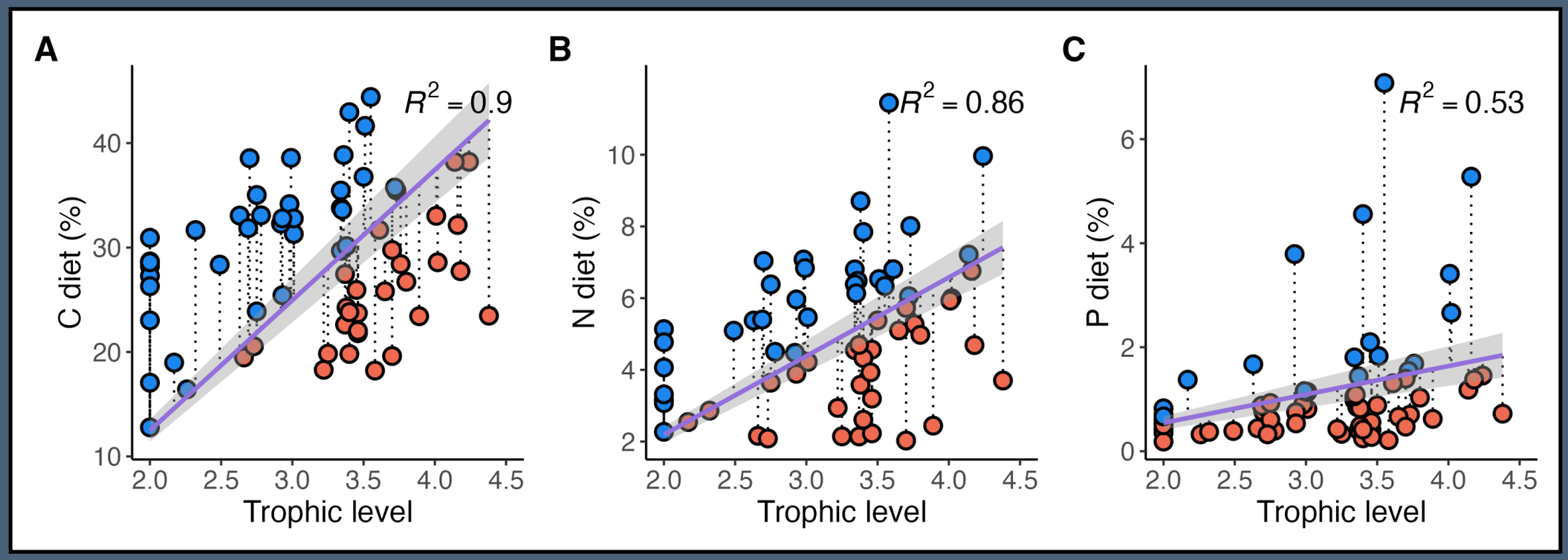
Trophic parameters

1) Trophic level
From FishBase

2) Element-specific assimilation efficiency
From literature: 0.8 for C and N, 0.7 for P

3) Element-specific body content percentage
From FishBase + Schiettekatte et al., 2021 + Phylogenetic interpolation

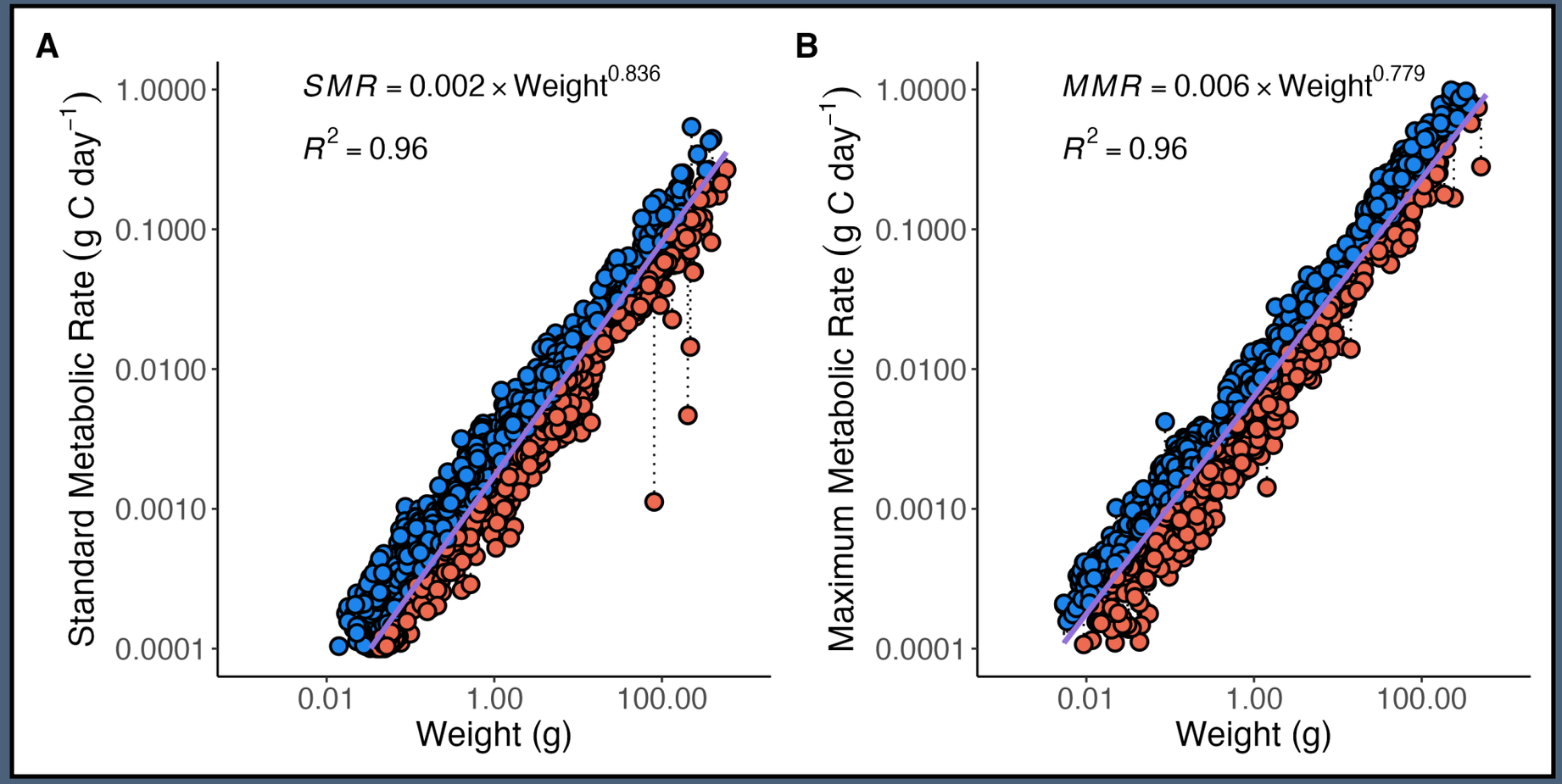
4) Elemental stoichiometry of diet
From FishBase + Schiettekatte et al., 2021 + Bayesian linear regression models



Metabolic parameters

1) Mass-specific turnover rate of N and P
From literature: 3.7e-03 for N and 3.7e-04 for P

2) Metabolic normalization constant of body mass (f_0), Mass scaling exponent (α) and Activity scope (θ)
They all depend of Standard and Maximum Metabolic Rates (SMR & MMR)
SMR = $f_0 \times Weight^{\alpha}$ and $\theta = 2SMR / (SMR + MMR)$
From Rosen et al., 2025 + Schiettekatte et al., 2021 + Vanni et al., 2017 + Bayesian loglinear regression models



What has been done so far?

Growth parameters (*in progress*)

1) Asymptotic Adult Length (L^{∞})
Will be done from FishBase

2) Growth Rate Parameter (K)
Will be done from FishBase

3) Age at Settlement (t_0)
Will be done from FishBase

4) Parameters length-weight relationship (lw_a and lw_b)
Will be done from FishBase

Morphologic parameters

1) Aspect ratio of caudal fin
From FishBase + Phylogenetic interpolation

Constant

1) Ratio of dry mass and wet mass of fish
From Literature: 25%–33%

Survey parameters (data)

What has been done so far?

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Survey parameters (data)

To sum up

parameters	retrieved
	✅
	✅
	✅
	✅
	✅
	❌

Brainstorm discussions

What kind of outputs?
We will be able to quantify the temporal functioning shift for each hexagonal cell,

We can also build on work from other members of B-Useful a relationship between global change and shifts in ecosystem functioning.

Points to consider that I'd love to get feedbacks:

- Sampling effort bias: Some hexagons have more catch data, likely due to longer sampling duration, which could introduce bias.
Proposed solution: Apply a randomization approach using a fixed number of observations per hexagon.
- Multi-functioning index: We can also scale all functions between 0 and 1 to construct a multivariate index (mean score of each function).
This would provide a more synthetic representation, though it may mask trade-offs between functions if some are compensated by others.
Proposed solution: Do both.

WP3 Biodiversity status and cumulative impacts

Task 3.3. Establish links to ecosystem functions and their associated services

Thank you for your outputs!

The whole framework is available here:

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