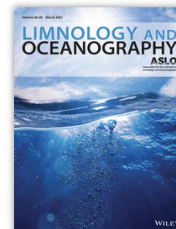


Functional trait-based approaches as a common framework for aquatic ecologists: Synthesis and recent results




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Functional trait-based approaches as a common framework for aquatic ecologists

Séverine Martini , Floriane Larras, Aurélien Boyé, Emile Faure, Nicole Aberle, Philippe Archambault, Lise Bacouillard, Beatrix E Beisner, Lucie Bittner, Emmanuel Castella, Michael Danger, Olivier Gauthier, Lee Karp-Boss, Fabien Lombard, Frédéric Maps, Lars Stemmann, Eric Thiébaud, Philippe Usseglio-Polatera, Meike Vogt, Martin Laviale, Sakina-Dorothee Ayata

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Functional trait-based approaches as a common framework for aquatic ecologists: Synthesis and recent results

**A collaborative work, involving
many freshwater and marine ecologists (FR, DE, NO, CA, US, CH)**

Sakina-Dorothee Ayata, Séverine Martini, Martin Laviale, Beatrix E Beisner,

Floriane Larras, Aurélien Boyé, Emile Faure, Nicole Aberle, Philippe Archambault, Lise Bacouillard, Lucie Bittner, Emmanuel Castella, Michael Danger, Olivier Gauthier, Lee Karp-Boss, Fabien Lombard, Frédéric Maps, Lars Stemmann, Eric Thiébaud, Philippe Usseglio-Polatera, Meike Vogt,



Functional trait-based approaches as a common framework

For whom?

For freshwater, marine, benthic, and pelagic ecologists



Lake Croche
Québec, Canada



Headwater stream,
Cleurie, France



Intertidal reefs,
English Channel, France

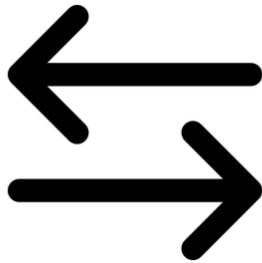


Bay of Villefranche-sur-mer
From a submarine, Med Sea

Functional trait-based approaches as a common framework

Why?

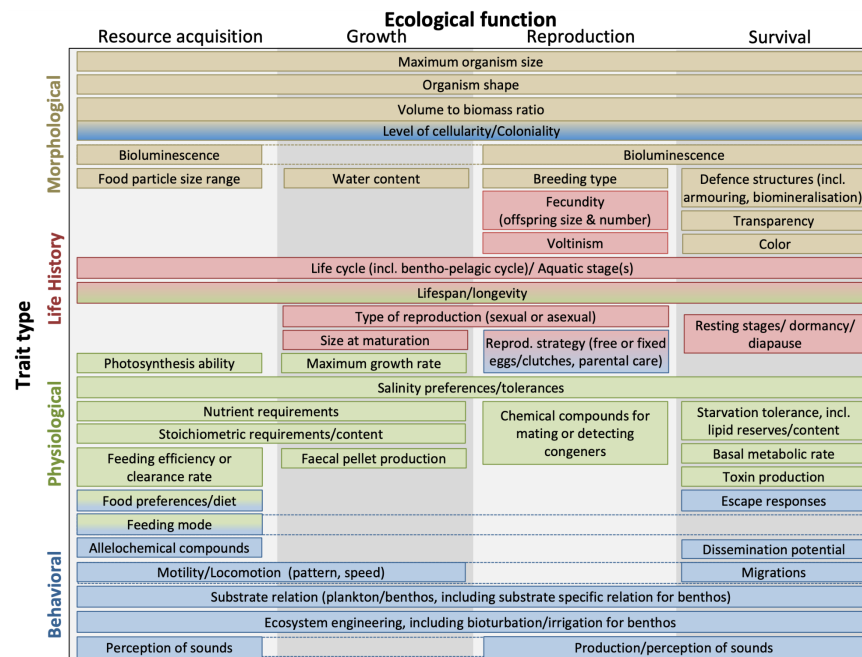
- Transcend local specificities and taxonomy
- Bridge communication gaps and foster knowledge sharing
- Provide a common ground and shareable tools to address common scientific challenges



Step 1: Adopting a common language

- Propose shared definitions (from what was available)
- Aquatic functional trait typology

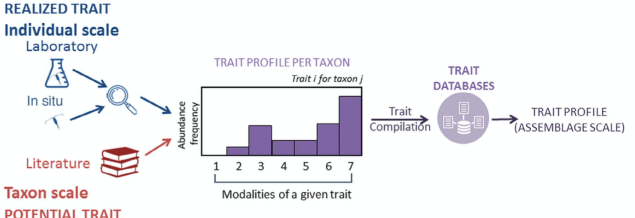
Term	Recommended definitions	References
Trait	Any morphological, physiological or phenological feature measurable at the individual level, from the cell to the whole-organism level, without reference to the environment or any other level of organization.	Violle et al. (2007)
Functional trait	Any trait that impacts fitness indirectly via its effects on growth, reproduction and survival.	Violle et al. (2007)
Realized trait	Trait actually measured in situ or in the laboratory	Reu et al. (2011)
Potential trait	Trait described from the literature, usually at the species level, and ideally covering a large variety of environmental conditions.	Reu et al. (2011)



Step 3: Listing methods

Synthesis on traditional as well as recent promising methods (imaging, omics)

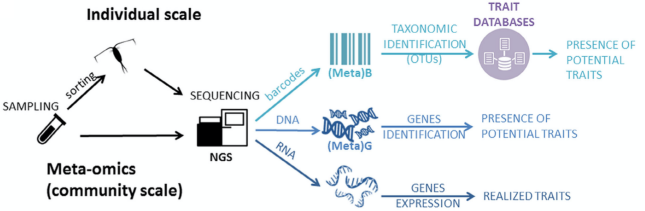
Lab or *in situ* measurements
Literature















Imaging

Imaging	Imaging	Imaging	Imaging	Imaging	Imaging	Imaging	Imaging	Imaging
SAMPLING	IMAGES/SOUNDS	FEATURE EXTRACTION	DATABASES	Taxa	Morphological traits	Behavioral traits	Life-History	Physiological
In the laboratory In situ				Copepoda Calanidae	Size Shape	Motility Migrations	Offspring size & number ...	Lipids reserve ...
					Transparency	Substrate relation Escape response		
					...	Bioluminescence Production of sound		

Sequencing (omics)

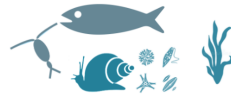






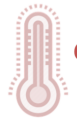





Highlighting challenges and promising avenues

Opportunities for aquatic trait-based approaches	
1) Documenting key traits	2) Spatial distribution of traits
<p>Multi-compartment studies</p>  <p>Intra-specific variability</p>  <p>Trade-offs</p> 	<p>Trait biogeography</p>  <p>Revealing hidden patterns</p>  <p>Spatial variability of functional diversity</p> 
3) Trait response to global change	4) Scaling up to ecosystem
<p>Temporal dynamics of traits</p>  <p>Trait-based biomonitoring</p>  <p>Climate change</p>  <p>Trait-based ecotoxicology</p> 	<p>Body size and trophic interactions</p>  <p>Stoichiometric traits</p> <p>C:N:P</p>  <p>From traits to global biogeochemical cycles</p>

Highlighting challenges and promising avenues

Usefulness of machine learning (images)

Opportunities for aquatic trait-based approaches	
<p>1) Documenting key traits</p> <p>Multi-compartment studies</p>  <p>Intra-specific variability</p>  <p>Trade-offs</p>	<p>2) Spatial distribution of traits</p> <p>Trait biogeography</p>  <p>Revealing hidden patterns</p>  <p>Spatial variability of functional diversity</p> 
<p>3) Trait response to global change</p> <p>Temporal dynamics of traits</p>  <p>Trait-based biomonitoring</p>  <p>Climate change</p>  <p>Trait-based ecotoxicology</p> 	<p>4) Scaling up to ecosystem</p> <p>Body size and trophic interactions</p>  <p>Stoichiometric traits</p> <p>C:N:P</p>  <p>From traits to global biogeochemical cycles</p>

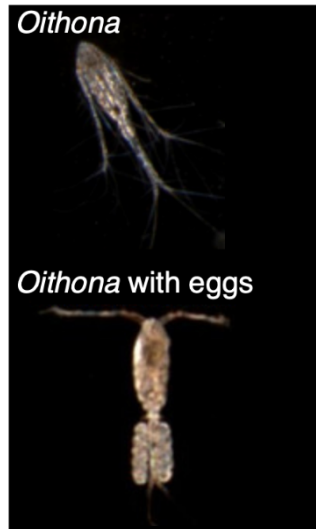
Mixotrophy in the ocean (omics)

Traits in regulatory biomonitoring

Stoichiometric traits

Example 1: Machine learning for measuring traits

Various algorithms can be used (example here: trait = size of copepod egg sacs)



Orenstein et al. (2022) L&O.
Machine learning techniques to characterize functional traits of plankton from image data

Example 1: Machine learning for measuring traits

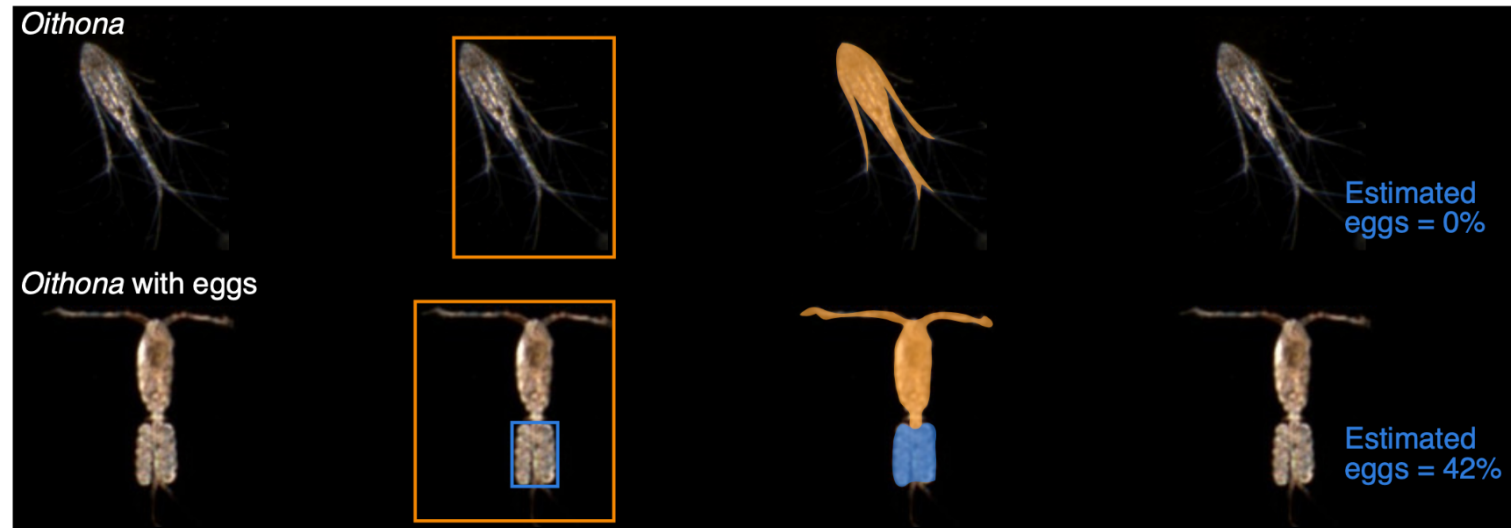
Various algorithms can be used (example here: trait = size of copepod egg sacs)

Classification

Object detection

Segmentation

Deep regression



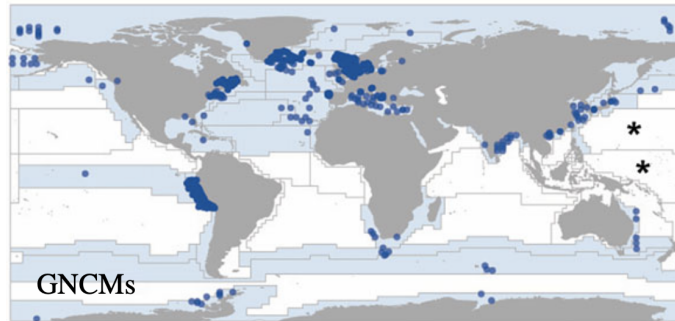
Orenstein et al. (2022) L&O.

Machine learning techniques to characterize functional traits of plankton from image data

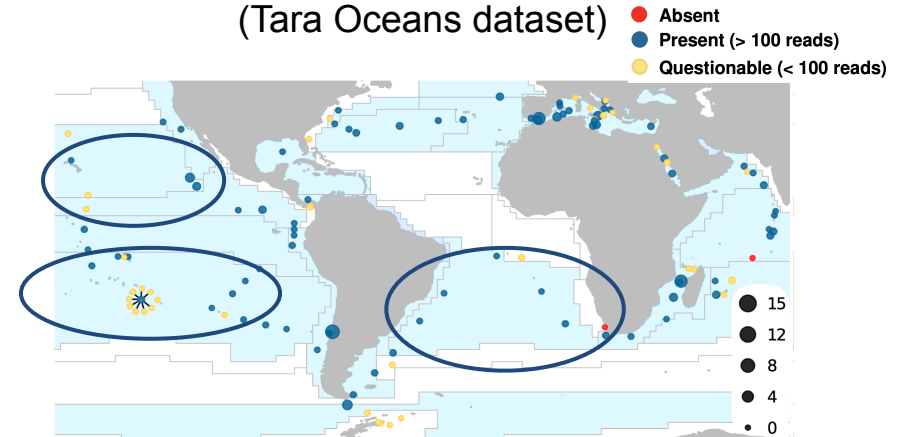
Example 2: Biogeography of mixotrophic traits

Using metabarcoding (exemple here: trait = generalist non-constitutive mixotrophy)

Field data review (Leles et al. 2017)
(no omics, Presence/Absence of 60 species)



Metabarcoding data
(Tara Oceans dataset)



Faure et al. (2019) ISME-J.

Mixotrophic protists display contrasted biogeographies in the global ocean

Example 3: Stoichiometric traits

= All traits related to organisms' elemental composition

To explain functional shifts in community composition & consequences for nutrient cycling

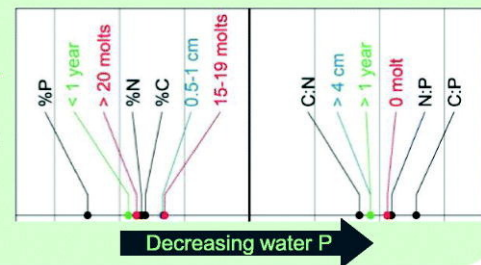
Here, traits = Community
Weighted Mean %P and N:P ratios



Altered community stoichiometry
→ altered nutrient pool provided by consumers
→ %C, %N, %P, molar C:N, C:P, N:P



Functional trait shifts in line with EST
→ P rich, fast-growing, fast-developing taxa under high P

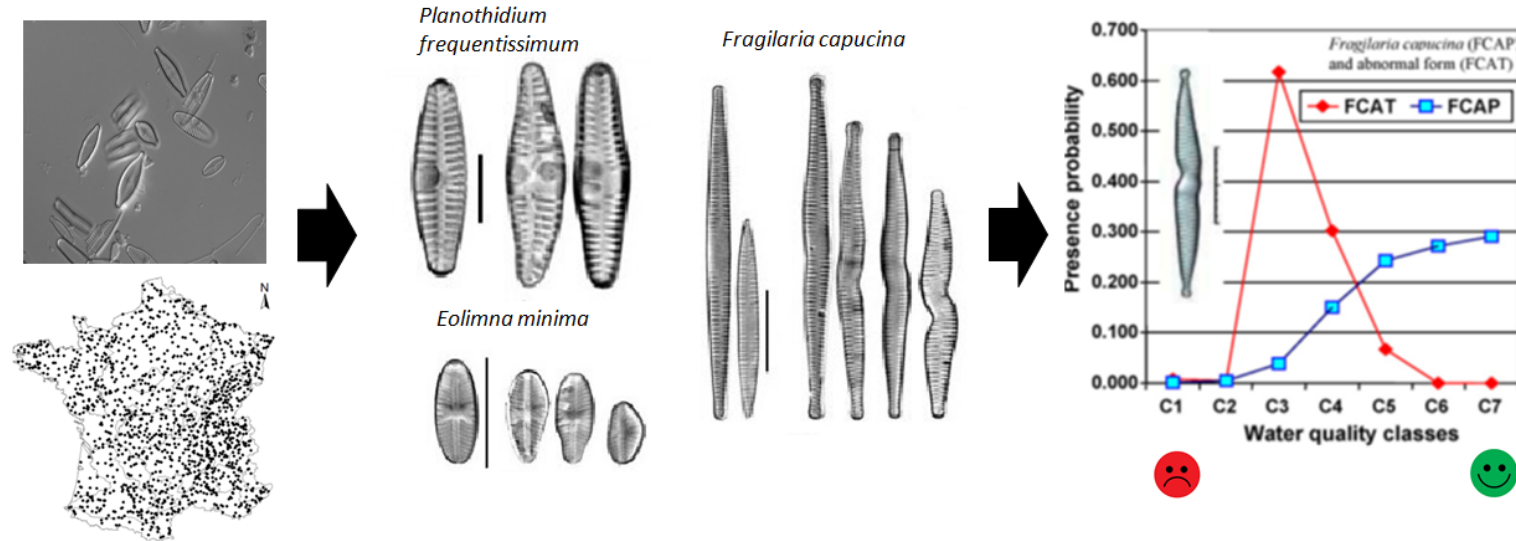


Beck et al. (2023) STOTEN

A 34-year survey under phosphorus decline and warming: Consequences on stoichiometry and functional trait composition of freshwater macroinvertebrate communities

Example 4: Biomonitoring

A crowd-sourcing approach for documenting diatom deformities

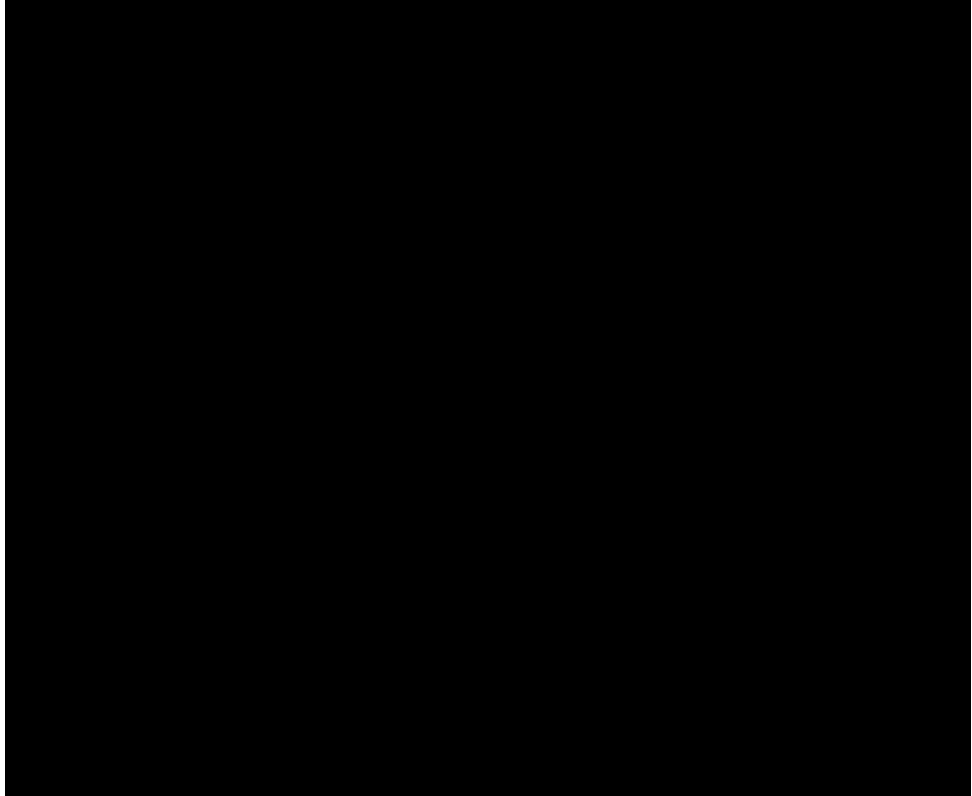


Vallanzasca et al. (2023) Bot. Let.

Development of a collaborative web platform documenting the diversity and extent of diatom deformities

Opportunities for training new ecologists!

- Interactive mental map



Opportunities for training new ecologists!

- Interactive mental map

