DEB2025 DEB practical course

May 26 – June 3, Heraklion, Crete, Greece

This advanced 8-day course on Dynamic Energy Budget (DEB) theory is designed to train participants in estimating DEB model parameters for their species and applying DEB theory in different contexts. Trainees will come together in Heraklion and interact with experienced scientists actively involved in applying DEB to their own research. The teaching team will deliver insightful lectures on applications of the theory across various fields, including environmental quality management, ecology, fisheries, and population dynamics. Beyond the coursework, this program fosters networking and strengthens international collaboration, making it an excellent platform for knowledge exchange and professional growth.

DEB2025 Team

Lecturers

André Gergs (A.G.), Michael (Mike) Kearney (M.K.), Sebastiaan (Bas) Kooijman (S.K.), Romain Lavaud (R.L.), Konstadia (Dina) Lika (D.L.), Gonçalo Marques (G.M.), Nina Marn (N.M.), Roger Nisbet (R.N.), Charlotte Récapet (C.R.), Tânia Sousa (T.S.), Tan Tjui-Yeuw (T.T-Y.), Jaap van der Meer (J.vdM)

Leaders Discussion Groups

Roger Nisbet; Nina Marn/Charlotte Récapet; Mike Kearney; Tan Tjui-Yeuw/Orestis Stavrakidis-Zachou; Maria Lagunes/Gonçalo Marques, Diogo F. Oliveira /Urban Dajcman

Assistants DEB-in practice and AmP workshops

Gonçalo Marques, Dina Lika, Charlotte Récapet, Bas Kooijman, Nina Marn, Urban Dajcman, Evridiki Klagkou, Maria Lagunes, Diogo F. Oliveira, Orestis Stavrakidis-Zachou

Plenary Discussion chairs

Mike Kearney (1st Plenary); Roger Nisbet (2nd Plenary)

AmP presentations chair

Mike Kearney

Onsite Support

Dina Lika, Evridiki Klagkou, Orestis Stavrakidis-Zachou

Timekeepers

Dina Lika, Gonçalo Marques (who will ring a bell to call the time).

Course schedule by day

Monday 26 May

09:00-10:00 "Welcome and Tele-course Summary" (D.L., G.M.)

10:00-11:00 "Overview of Typified DEB models & Tools" (D.L.)
11:00-11:30 Break
11:30-12:30 "DEB and the ecological niche" (M.K.)
12:30-14:00 Lunch
14:00-16:00 DEB in practice "DEB model Simulations" (M.K.)
16:00-16:30 Break
16:30-17:30 "Life: from molecules to system earth" (S.K)
17:30-18:30 Discussion groups

Tuesday 27 May

09:00-10:00 "Accelerations and evolution of acceleration" (S.K.)
10:00-11:00 Discussion groups
11:00-11:30 Break
11:30-12:30 DEB in practice "AmP Parameter Estimation" (D.L)
12:30-14:00 Lunch
14:00-15:00 AmP projects: Setting up (N.M.)
15:00-16:00 AmP projects
16:00-16:30 Break
16:30-18:30 AmP projects

Wednesday 28 May

09:00:10:00 "DEB and environmental limits" (M.K.)
10:00-11:00 Discussion Groups
11:00-11:30 Break
11:30-12:30 "Synthesizing Units" (G.M.)
12:30-14:00 Lunch
14:00-16:00 DEB in practice "Running DEB models in NicheMapR" (M.K.)
16:00-16:30 Break
16:30-18:30 AmP projects

Thursday 29 May

09:00-10:00 "DEB in ecotoxicology" (R.N.)
10:00-11:00 "Patterns in parameter values" (S.K.)
11:00-11:30 Break
11:30-12:30 DEB in practice "DEB tools to trait based ecology" (T.T-Y.)
12:30-14:00 Lunch
14:00-15:00 Plenary Discussion (M.K.)
15:00-16:00 AmP projects
16:00-16:30 Break
16:30-18:30 AmP projects

Friday 30 May

09:00-10:00	"Lessons learned in ecotoxicology crossing scales of organization" (R.N.)
10:00-11:00	Discussion Groups
11:00-11:30	Break
11:30-12:30	"DEB theory and evolutionary theories on life-history" (C.R.)
12:30-14:00	Lunch
14:00-15:00	“Respiration and macro-chemical reaction equations in practice” (G.M.)
15:00-16:00	"Parameter Identifiability" (D.L.)
16:00-16:30	Break
16:30-18:30	AmP projects

Saturday 31 May

09:00-10:00	"Intraspecific variation in a DEB framework" (C.R.)
10:00-11:00	Discussion Groups
11:00-11:30	Break
11:30-12:30	"DEB modules and applications" (N.M.)
12:30-14:00	Lunch
14:00-15:00	"Multivariate DEB models" (G.M.)
15:00-16:00	AmP projects
16:00-16:30	Break
16:30-18:30	AmP projects

Sunday 1 June

Day off

Monday 2 June

09:00-11:00	"Canonical community" (J.vdM.)
11:00-11:30	Break
11:30-12:45	Discussion Groups
12:45-14:00	Lunch
14:00-15:00	"The Structure of DEB theory" (T.S.)
15:00-16:00	AmP projects
16:00-16:30	Break
16:30-17:30	"Thermodynamics of life" (T.S.)
17:30-18:30	Plenary Discussion (R.N.)

Tuesday 3 June

09:00-11:00	DEB in practice "Ecotoxicology workshop" (A.G.)

11:00-11:30	Break
11:30-12:45	DEB in practice "Ecotoxicology workshop" (A.G.)
12:45-14:00	Lunch
12:00-16:00	AmP presentations
16:00-16:30	Break
16:30-18:00	AmP presentations
18:00-18:30	Q&A / Closing remarks

AmP projects (14 H)

Objective: estimate parameters for "multiple models that share parameters and are fitted to multiple data sets" using 1 food, 1 reserve, 1 structure DEB model for an animal. In addition to the task and learning objectives outlined below, the AmP workshop will also be used to provide Matlab and DEBtool training and basics in statistical and numerical methods for those who have an interest in it.

Tasks

- Create a "predict_my_pet" file specific to your project animal.
- Utilize the "run_my_pet" function to estimate parameter values for your project animal.
- Calculate and analyze over 100 implied properties for your project animal.

Tasks will be further outlined based on participant level and objectives during the "AmP projects: setting up" on Tuesday, 27 May. It is very important to come prepared with both a discussion topic and compiled physiological data (with references) on an animal of your choice. The specific tasks defined here will form the basis for the following 13 hours of project time.

Learning objectives

- Develop the ability to generate user-defined predictions for an animal's length, weight, respiration, and reproduction using multiple models.
- Acquire skills to estimate parameters using diverse sets of data.
- Analyze and evaluate goodness of fit by assessing the distance and accuracy of predictions compared to observed data.
- Demonstrate an understanding of the biological context by discussing the goodness of fit in relation to phylogenetic and ecological factors.

Assessment

Alone or in a small group present the findings (up to 7 min/person). This will be on the final day of the course (Tuesday, 03 June).

Animals used for each Project

First Name	Animal (Latin Name)	Animal (English Name)	GitHub Name	In AmP
Alejandra	*Pleuronectes platessa*	Plaice	alejandraortizduran	Yes
Anamarija	*Rhoptropus afer*	Namib day gecko	anamarijaz	No
Anna	*Callorhinus ursinus*	Northern Fur Seal	sulcaa	Yes
Alex Coverley	*Onthophagus taurus*	dung beetle	Ac0ver	Yes
Alex Robinson	*Mamestra brassicae*			No
Caroline	*Streptocephalus vitreus*		Caroline-Ianniello	Yes
Christine	fairy shrimp		CEVerhille	
Clarisa	*Chironomus xanthus*		ClarisaMarekO	No
Dana	*Orius laevigatus*	Minute pirate bug	dbashkir	Yes
David Deslauriers	*Sebastes mentella*, *Sebastes fasciatus*		davelerouge995	Yes Yes
David Schneider	*Bembidion lampros*		SchneiderDM82	No
Elisa	*Sardina pilchardus*, *Engraulis encransicolus*	E. sardines anchovies		Yes
Fabio	*Amazona pretrei*	Red-spectacled amazon parrot		No
Familusi	*Homarus americanus*	American Lobster		Yes
Gaia	*Mytilus edulis*	Blue Mussel	ggrieco00	Yes

Gitai		A bivalve or sponge	GiatiYahel	
Jake	*Antidorcas marsupialis Loxodonta africana*		JakeBritnell	Yes
Jason	*Plectropomus oligacanthus*		JAHale-upc	No
Katerina	*Acartia tonsa*		kpitsika	No
Kevan	*Dendroctonus ponderosae*	Mountain pine beetle	KevanRastello	No
Killian	*Pangasianodon hypophthalmus*	striped catfish	KillianCh90	Yes
Louisa	*Lithobates catesbeianus*	American bullfrog	Luisaviegas	Yes
Louis Miguel	*Leptodactylus podicipinus*	Pointedbelly Frog		No
Maria	*Primnoa resedaeformis*		rakkam	No
Marina	*Gammarus pulex*	Freshwater shrimp	@marveseli	Yes
Matthieu	Dicentrarchus labrax	E. sea bass		Yes
Suncana	*Perna canaliculus*	New Zealand green-lipped mussel	SuncanaG	Yes
Tasos	*Podarcis bocagei*	Bocage's wall lizard	Limnios-A	No
Taylor	*Astrangia poculata*	Northern Star Coral	taylor-lindsay	No
Tim	*Mytilus edulis*	Blue Mussel	TimDEB237	Yes
Tristan	*Pygoscelis papua*	Gentoo penguin	Tristan291	

Urban	*Podarcis muralis, Iberolacerta horvathi, Strix uralensis*	common wall lizard, Horvath's rock lizard, Ural owl	UrbanDajcman	Yes
Yannis	*Plectropomus pessuliferus*	roving coral grouper	YannisHatzo	No
Zihan	*Moloch horridus*	Thorny devil	z1han-zhou	Yes

Discussion Groups

Please find any DEB related paper in the DEB zotero library (you can access PDFs for free when you are a member).

7/8 participants per group discussion. The chair(wo)man will appoint a reporter, who will summarize the discussion during the plenary discussions. In each scheduled hour, 2 participants have 10 min to expose the problem and question(s) that they submitted in preparation for the course, followed by a 10 min discussion per presentation. In the remaining time (some 20 min per hour) we will discuss a topic related to DEB theory:

TOPIC 1 (May 26, 27 & 28): From Formulae to Theories

Mathematical methods are essential for quantitative models and theories. The journey from simple mathematical formulae to comprehensive theories is often mediated by well-constructed models. How do we distinguish between a formula, a model, and a theory? What practices are essential for moving from descriptive to explanatory models in biology? What is the difference between a 'mechanistic' and 'correlative' model? What makes DEB models generalizable across species and contexts?

- Kooijman et al. (2024) From formulae, via models to theories: Dynamic Energy Budget theory illustrates requirements. *Ecological Modelling*, 497, 110890. https://doi.org/10.1016/j.ecolmodel.2024.110869
- Kearney et al (2021) What Is the Status of Metabolic Theory One Century after Pütter Invented the von Bertalanffy Growth Curve? Biol. Rev, 96, https://doi.org/10.1111/brv.12668

TOPIC 2 (May 30, 31 & June2): Good Modeling Practice

Modeling serves a wide range of purposes, from understanding complex systems and generating hypotheses, to predicting future behavior or informing experiments. However, the value of any model is fundamentally shaped by how it is constructed, validated, documented, and shared. This discussion invites participants to explore the core principles of Good Modeling Practice (GMP) and examine how practices like early adoption of software standards, open-source code sharing, and modular design affect the reliability and longevity of scientific models.
Key questions for GMP thus include: What principles define good modeling practice? In what ways do reusable model components and shared libraries advance GMP? What are the benefits and obstacles of integrating good software practices early in model development? How does open-source code contribute to GMP? How does GMP support the transition from descriptive models to explanatory frameworks and generalizable theories? And how important is internal consistency for the credibility and utility of a model? A relevant example comes from metabolic modeling, where production models remain widely used. In these models, food intake is converted to energy, from which respiration is subtracted; the remaining portion is allocated to production, i.e. growth, reproduction, and feces. The Scope-for-Growth (SfG) concept is based on this logic, as is the widely used Wisconsin model. However, the existence of growth-overheads—energy costs that contribute to respiration—raises questions about the internal consistency of this bookkeeping. To to what extend is this bookkeeping consistent? How important is consistency for model assumptions?

- Grimm et al. (2010) The ODD Protocol: A Review and First Update. *Ecological Modelling*, 221, 2760-2768. https://doi.org/10.1016/j.ecolmodel.2010.08.019
- Jakeman et al. (2024) Towards normalizing good practice across the whole modeling cycle: its instrumentation and future research topics. *Socio-Environmental Systems Modelling*, *6*, 18755. https://doi.org/10.18174/sesmo.18755
- Meir et al. (2025) Model perpetuation by designing and documenting models and workflows so that they can be reused and further developed by others: The case of multiple stressors in ecology. Ecological Modelling, 501, 111029. https://doi.org/10.1016/j.ecolmodel.2025.111029
- Lemmen et al. (2024) Good modelling software practices, Ecological Modelling, 498, 110890. https://doi.org/10.1016/j.ecolmodel.2024.110890

Plenary Discussions (2 H)

The reporters of the discussion groups report at the plenary session for 5 min each, leaving some 30 min for discussion with all the participants simultaneously.

AmP presentations (3.5 H)

On the final day (June 3), participants can briefly present their results, issues, and next steps, and will receive feedback from the teaching team. If time permits, we will compare the parameter values and provide a concise summary of the findings.

Lecture contents (19 H)

Michael Kearney

Lecture 1: “DEB, functional traits and the ecological niche”

This lecture will introduce a way of thinking about the ecological niche that focuses on individuals as thermodynamic systems, linking theory about heat and water exchange (biophysical ecology) with DEB theory. It will discuss the concept of ‘functional traits’ viewed through this perspective.

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Lecture 2: “DEB and environmental limits”

This lecture will work through some examples of coupling biophysical ecology and DEB theory in practice and discuss perspectives that this provides for understanding environmental limits.

References

Kearney, M.R., Enriquez-Urzelai, U., 2022. A general framework for jointly modelling thermal and hydric constraints on developing eggs. Methods in Ecology and Evolution. https://doi.org/10.1111/2041-210X.14018

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Bas Kooijman

Lecture 1: “Life: from molecules to system earth”

- This lecture discusses conceptual aspects of links between the molecular and system earth levels of life and the role of individuals.

- Limitations of mathematical modeling are discussed in the light of scales in space and time.
- Ideas are presented on the evolution of the central metabolism and how they can be used to delineate metabolic modules between molecules and individuals.
- Mass and energy balances at the population level can structure canonical communities in ways that respect the syntrophic nature of life on earth.
- Geochemical recycling processes shaped the evolution of life; examples are given.

References:

Meer, J. van der, Hin, V. Oort, P. van & Wolfshaar, K.E. van der 2022
A simple DEB-based ecosystem model. Cons. Physiol. 10: coac057
Kooijman, S.A.L.M., Lika, K., Augustine, S., Marn, N. & Kooi, B.W. 2020
The energetic basis of population growth in animal kingdom. Ecol. Mod, 428: 109055
Kooijman, S.A.L.M. & Troost, T.A. 2007
Quantitative steps in the evolution of metabolic organization as specified by the Dynamic Energy Budget theory. Biol. Rev 82: 1-30
Meer, J. van der 2016
A paradox in individual-based models of populations. Cons. Physiol. 4 cow023
Kooijman, S.A.L.M. & Hengeveld, 2005
The symbiotic nature of metabolic evolution.
In: Reydon & Hemerik (eds): current themes in Theoretical Biology. Springer
Kooijman, S.A.L.M. 2004
On the coevolution of life and its environment.
In: Schneider et al (eds): Scientists Debate Gaia; the next century. Cambridge, Mass
Kooijman, S.A.L.M, Auger, P., Poggiale, J.C. & Kooi, B.W. 2003
Quantitative steps in symbiogenesis and the evolution of homeostasis. Biol. Rev. 78: 435-463
Nisbet, R.M., Muller, E.B., Lika, K. & Kooijman, S.A.L.M. 2000
From molecules to ecosystems through Dynamic Energy Budget models. J. Anim. Ecol. 69: 913-926

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Lecture 2: "Acceleration and the evolution of acceleration"

- I will review the 5 different types of metabolic acceleration that have been delineated so far.
- The most frequently occurring type, the Morph-type, structures the DEB models that are used in AmP.
- The key is how surface areas (assimilation) relate to volumes (maintenance).
- Definitions and examples will be given for each type.

References:

Add-my-Pet database:
https://www.bio.vu.nl/thb/deb/deblab/add_my_pet/
Marques, G.M., Lika, K., Pecquerie, L., Domingos, T. & Kooijman, S.A.L.M. 2018

The AmP project: Comparing Species on the Basis of Dynamic Energy Budget Parameters. PLOS Comp. Biol. 14: e1006100
Kooijman, S.A.L.M. 2014
Metabolic acceleration in animal ontogeny: An evolutionary perspective. J. Sea Res. 94: 128-137

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Lecture 3: "Patterns in Parameter values"

- Building on my acceleration lecture, I will review 4 other general patterns in DEB parameter values that have been found so far.
- Apart from the physical co-variation rules, waste-to-hurry shaped Kleiber's 3/4-rule.
- Patterns found in sharks show, however, why the body-size scaling of respiration is a poor predictor for other traits.
- The supply-demand and altricial-precocial spectra are discussed.
- Ideas are presented for why mammals evolved from altricial to precocial, while birds did so in the opposite direction.

References

Add-my-Pet database:
https://www.bio.vu.nl/thb/deb/deblab/add_my_pet/
Augustine, S., Lika, K. & Kooijman, S.A.L.M. 2022
The comparative energetics of the chondrichthyans reveals universal links between respiration, reproduction and life span. J. Sea Res. 185: 102228
Kooijman, S.A.L.M. & Augustine, S. 2022
The comparative energetics of the cephalopods: they neither grow nor reproduce fast. J. Sea Res. 184: 102205
Kooijman, S.A.L.M., Lika, K., Augustine, S. & Marn, N. 2021
Multidimensional scaling for animal traits in the context of dynamic energy budget theory. Cons. Physiol. 9: coab086
Lika, K., Augustine, S. & Kooijman, S.A.L.M. 2019
Body size as emergent property of metabolism. J. Sea Res. 143:8-17
Augustine, S., Lika, K. & Kooijman, S.A.L.M. 2019
Altricial-precocial spectra in animal kingdom. J. Sea Res. 143: 27-34
Augustine, S., Lika, K. & Kooijman, S.A.L.M. 2019
Why big-bodied animal species cannot evolve a waste-to-hurry strategy. J. Sea Res. 143: 18-26
Marques, G.M., Lika, K., Pecquerie, L., Domingos, T. & Kooijman, S.A.L.M. 2018
The AmP project: Comparing Species on the Basis of Dynamic Energy Budget Parameters. PLOS Comp. Biol. 14: e1006100
Kooijman, S.A.L.M. & Lika, K. 2014
Resource allocation to reproduction in animals. Biol. Rev. 89: 849-859
Lika, K, Augustine, S., Pecquerie, L. & Kooijman, S.A.L.M. 2014
The bijection from data to parameter space with the standard DEB model quantifies the supply-demand spectrum. J. Theor, Biol. 354: 35-47
Kooijman, S.A.L.M. 2014

Metabolic acceleration in animal ontogeny: An evolutionary perspective. J. Sea Res. 94: 128-137
Kooijman, S.A.L.M. 2013
Waste to hurry: Dynamic Energy Budgets explain the need of wasting to fully exploit blooming resources. Oikos 122: 348-357
Kooijman, S.A.L.M 1986
Energy budgets can explain body size relations. J. Theor. Biol. 121: 269-282

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Dina Lika

Lecture 1: "Overview of Typified DEB models & Tools"

- Standard DEB model
- Isomorphy, V1-morphy
- Types of DEB parameters
- Typified DEB models
- Extensions of DEB models
- Tools for simulating individual dynamics in constant and varying food/temperature

G.M. Marques, S. Augustine, **K. Lika**, L. Pecquerie and S.A.L.M. Kooijman. 2018. The AmP project: Comparing Species on the Basis of Dynamic Energy Budget Parameters. PloS *Computational Biology*, 14(5): e1006100 doi.org/10.1371/journal.pcbi.1006100

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Lecture 2: “Parameter Identifiability”

- Structural and practical identifiability
- Quantifying accuracy of parameters of deterministic models
- Model plasticity
- Handling non-identifiable parameters
- Confidence intervals

C.M. Marques, K. Lika, S. Augustine, L. Pecquerie, S.A.L.M. Kooijman. 2019. Fitting multiple models to multiple data sets. *Journal of Sea Research*, 143, 48-56. https://doi.org/10.1016/j.seares.2018.07.004

K. Lika**,** S.A.L.M. Kooijman. 2024. The relationship between confidence intervals and distributions of estimators for parameters of deterministic models. *Ecological Modelling*, 490: 110645. https://doi.org/10.1016/j.ecolmodel.2024.110645

Gonçalo Marques

Lecture 1 " Tele-course Summary "

Opening remarks, orientation
Summary of tele-course
Core principles of DEB theory

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Lecture 2: “Synthesizing Units”

- What are SUs good for?
- One more conservation: conservation of time
- One example on how to estimate fluxes with SUs

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Lecture 3: “Multivariate DEB models”

- When to multiply State variables?
- Multiple substrates
- Multiple reserves
- Multiple structures
- Multiple modules

Required visualization: Multivariate DEB Models

Lecture 4: “Respiration and macro-chemical reaction equations in practice”

TBA

Nina Marn

Lecture 1: “DEB Modules and Applications”

- Feeding module

- Starvation
- Reproduction module
- Reconstructions

References:

- Lika, K., & Papandroulakis, N. (2005). Modeling feeding processes: a test of a new model for sea bream (Sparus aurata) larvae. Can. J. Fish. Aquat. Sci., 62, 425–435.
- Saraiva, S., Meer, J. van der, Kooijman, S. A. L. M., & Sousa, T. (2011). Modelling feeding processes in bivalves; a mechanistic approach. Ecol. Modelling, 222, 514–523.
- Kooijman, S. A. L. M. (2006). Pseudo-faeces production in bivalves. J. Sea Research, 56, 103–106.
- Marn, N., Jusup, M., Kooijman, S. A. L. M., & Klanjšček, T. (2020). Quantifying impacts of plastic debris on marine wildlife identifies ecological breakpoints. Ecology Letters, 23, 1479–1487. https://doi.org/10.1111/ele.13574
- Pecquerie et al. (2009) Modeling fish growth and reproduction in the context of the Dynamic Energy Budget theory to predict environmental impact on anchovy spawning duration. J. Sea Res. 62:93-105
- Augustine et al. (2012) Effects of uranium on the metabolism of zebrafish, Danio rerio. J. Sea Res. 62:93-105
- Murphy et al. (2018) Incorporating Suborganismal Processes into Dynamic Energy Budget Models for Ecological Risk Assessment . *IEAM* 14(5):615–624
- Firkus, Lika, Murphy (2023) The consequences of sea lamprey parasitism on lake trout energy budgets. *Conserv Physiol* 11(1): coad006
- Marn, N., Lika, K., Augustine, S., Goussen, B., Ebeling, M., Heckmann, D., & Gergs, A. (2022). Energetic basis for bird ontogeny and egg-laying applied to the bobwhite quail. Conservation Physiology, 10(1), coac063. https://doi.org/10.1093/conphys/coac063
- Pethybridge, et al. (2013) Responses of European anchovy vital rates and population growth to environmental fluctuations: An individual-based modeling approach. Ecol. Model. 250, 370–383. https://doi.org/10.1016/j.ecolmodel.2012.11.017
- Augustine et al. (2013) Stochastic feeding in fish larvae and their metabolic handling of starvation. J of Sea Res 66 (2011) 411–418
- L. Pecquerie et al., “Reconstructing Individual Food and Growth Histories from Biogenic Carbonates,” Mar. Ecol. Prog. Ser. 447 (2012): 151–164.
- Lavaud, Romain, Eric Rannou, J. Flye Sainte Marie, and Fred Jean. “Reconstructing Physiological History from Growth, a Method to Invert DEB Models.” Journal of Sea Research 143 (2019): 183–192.

Roger Nisbet

Lecture 1: “Dynamic Energy Budget theory in ecotoxicology”

• Ecotoxicology: effects of toxic substances on living organisms at multiple levels of ecological organization
• Why develop general theory? Too many chemicals, organisms, environments
• Toxicokinetics (TK) and toxicodynamics (TD)
• Modeling triad: DEB/TK/TD
• DEB-based modeling of lethal effects: damage and survival (GUTS)
• DEB-based modeling of sublethal effects: physiological modes of action (pMoA)

• Practical challenges

Reference:

Jager T (2019). Making Sense of Chemical Stress. Application of Dynamic Energy Budget Theory in Ecotoxicology and Stress Ecology. Leanpub: https://leanpub.com/debtox_book.

Lecture 2: “Lessons learned in ecotoxicology crossing scales of organization”

DEB as “pivot” linking sub-organismal biology to higher levels of ecological organization

• Individual-to-population: DEB-IBM (connects with DEB-in-Practice: "Importance of toxicants' Mode of Actions to predict population outcomes”)
• Adverse Outcome Pathways (AOP)
• AOP-to-DEB: challenges in linking AOP to pMoA in DEB theory
• So much more needed!

References:

B. Martin et al. (2014). Limitations of extrapolating toxic effects on reproduction to the population level. Ecological Applications, 24, pp. 1972–1983.
C.A. Murphy et al. (2018). Incorporating Suborganismal Processes into Dynamic Energy Budget Models for Ecological Risk Assessment, Integrated Environmental Assessment and Management, DOI: 10.1002/ieam.4063

Charlotte Récapet

Lecture 1: “DEB theory and evolutionary theories on life-history”

Learning outcomes

After this lecture, you should be able to

- Explain the main theories/explanations on life-history variation among animals
- Discuss the generality of their application (interspecific vs. intraspecific, specific taxa or environmental conditions) and the strength of their empirical support
- Interpret empirical life-history patterns and theories in the light of DEB theory

Topics

life-history strategies, evolutionary trade-offs, alternative tactics, r and K-selected species, supply-demand spectrum, pace-of-life syndrome, waste-to-hurry strategy

References

- Stearns 1992. The evolution of life histories. Oxford University Press, Oxford
- Ricklefs and Wikelski 2002. The physiology/life-history nexus. *Trends Ecol. Evol.*, 17, 462–468.
- Royauté, Berdal, Garrison, et al. 2018. Paceless life? A meta-analysis of the pace-of-life syndrome hypothesis. *Behav Ecol Sociobiol* 72, 64
- Montiglio, Dammhahn, Messier, and Réale 2018. The pace-of-life syndrome revisited: the role of ecological conditions and natural history on the slow-fast continuum. *Behav. Ecol. Sociobiol.*,72, 116.
- Lika, Augustine, Pecquerie, and Kooijman 2014. The bijection from data to parameter space with the standard DEB model quantifies the supply–demand spectrum. *Journal of theoretical biology*, 354, 35-47.

Lecture 2: “Intraspecific variation in a DEB framework”

Learning outcomes

After this lecture, you should be able to

- Explain the relevance of mechanistic approaches for integrating genetic and environmental variation
- Predict qualitatively the phenotypic differences resulting from variation in DEB parameters and environmental variables
- Understand the advantages and limits of different approaches to estimate intraspecific variation in DEB parameters, from sub-species to individuals
- Illustrate the ecological impact of intraspecific variation using examples from aquatic species

Topics

gene-by-environment interactions, plasticity, micro-evolution, evolutionary constraints

References

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- Roff 1996. The evolution of threshold traits in animals. *Q. Rev. Biol.* 71(1), 3-35
- Nisbet et al. 2016. Integrating ecological insight derived from individual-based simulations and physiologically structured population models. *Ecol. Model.* 326, 101-112
- Monaco 2019. Predicting the performance of cosmopolitan species: dynamic energy budget model skill drops across large spatial scales. *Marine Biol.* 166, 14
- Jager 2013. All individuals are not created equal; accounting for interindividual variation in fitting life-history responses to toxicants. *Environ. Sci. Technol.* 47, 3, 1664-1669
- Lika et al. 2020. The use of augmented loss functions for estimating dynamic energy budget parameters. *Ecol. Model.* 428, 109110

- Sadoul et al. 2020. Multiple working hypotheses for hyperallometric reproduction in fishes under metabolic theory. *Ecol. Model.* 433, 109228

Tânia Sousa

Lecture 1: “The Structure of DEB Theory”

Building on Sousa et al. (2008), here we show that DEB theory can be built from 1) the fundamental thermodynamic constraints that all processes obey mass and energy conservation but lead to entropy production, 2) a physical assumption of quite general applicability, that local flows are proportional to differences in intensive variables (and, hence, total flows are proportional to surface areas), 3) a biological assumption, that cells are metabolically very similar, independently of the organism or its size, and, 4) in a “systems theory” type of approach, an application of Occam’s razor, in always choosing the simplest possible formulation of a mathematical theory (minimize the number of state variables; choose linear over non-linear functions; minimize the number of parameters).

Having condensed DEB theory in this compact definition, we then show how these fundamental assumptions lead to the strong and weak homeostasis principles, and then to partitionability of reserve dynamics and the reserve dynamics itself. With this, we obtain the von Bertallanfy growth curve and Kleiber’s rule, for intra- and inter-specific comparisons.

- Sousa, T., T. Domingos, S. A. L. M. Kooijman, 2008, From empirical patterns to theory: A formal metabolic theory of life, Philosophical Transactions of the Royal Society of London B 363: 2453–2464

Lecture 2: “Thermodynamics of life”

Metabolism: The effect of temperature
Aggregated chemical reactions
Mass, energy, and entropy balances in organisms.

Jaap van der Meer

Lecture 1: “Canonical community”

TBA

DEB-in-Practice contents (11 H)

"DEB model Simulations" - Mike Kearney

Simulating the DEB model for different species using online simulators
http://bioforecasts.science.unimelb.edu.au/app_direct/deb_sea/
http://bioforecasts.science.unimelb.edu.au/app_direct/deb/

"AmP Parameter Estimation" - Dina Lika

Learning objectives

- Understand and apply the concept of fitting multiple models, which share parameters, to multiple data sets, which may differ in dimensions, in a single parameter estimation.
- Be able to prepare the 4 AmP source files to do the AmP parameter estimation.
- Learn how to configure and customize the options for running the parameter estimation procedure.
- Develop skills for evaluating the quality of parameter estimates and model fit by comparing simulated and observed data, assessing goodness-of-fit.

DEB parameter estimation: https://debportal.debtheory.org/docs/AmPestimation.html
Data types: https://debportal.debtheory.org/docs/AmPestimation.html#Data
Spurdog: Squalus acanthias entry:
http://www.bio.vu.nl/thb/deb/deblab/add_my_pet/entries_web/Squalus_acanthias/Squalus_acanthias_res.html

Data Sheet: for filling out the example entry and going over each step of the estimation procedure:

- C.M. Marques, S. Augustine, K. Lika, L. Pecquerie and S.A.L.M. Kooijman. 2018. The AmP project: Comparing Species on the Basis of Dynamic Energy Budget Parameters. PloS *Computational Biology*, 14(5): e1006100 doi.org/10.1371/journal.pcbi.1006100
- C.M. Marques, K. Lika, S. Augustine, L. Pecquerie, S.A.L.M. Kooijman. 2019. Fitting multiple models to multiple data sets. *Journal of Sea Research*, 143, 48-56. https://doi.org/10.1016/j.seares.2018.07.004

Download zip folder with files for working

"AmP project Setting Up" - Nina Marn

- Know the difference between core DEB theory assumptions and auxiliary theory assumptions
- Know how to navigate the AmP database and associated resources to find user-defined predictions for you type of data
- Description of files

"Running DEB models in NicheMapR" - Mike Kearney

NicheMapR, R, R Studio as well as the R.matlab package
The link below is ~40 meg and is the output of the microclimate model for one of the examples – people could download that if they want to save some time because it takes ages to download the data needed for that simulation from the web (just because of the weird nature of the connection to the database rather than it being a lot of data).

"DEB tools to trait based ecology" - Tan Tjui-Yeuw

AmPtool: https://amptool.debtheory.org/docs/index.html
Templates we will work with are in https://github.com/add-my-pet/SI
AmP Ecology coding: http://www.bio.vu.nl/thb/deb/deblab/add_my_pet/AmPeco.html
Survivor plot of empirical data
Survivor function
Plotting DEB traits and parameters in practice

"Ecotoxicology workshop" - Andre Gergs

During the workshop, I will provide a very brief introduction into (aquatic) ecotoxicology and the use of DEB models for evaluating chronic toxicity studies. We will work with a data set where water fleas (*Daphnia magna*) were exposed to different concentrations of silver nanoparticles.

Learning objectives

- Familiarize with basics concepts of aquatic ecotoxicology and simplified TK-TD models, including scaled damage dynamics, chemical stress and physiological modes of action.
- Being able to handle a toxicity data set in an AmP estimation environment.
- Learn how to configure the options for running the parameter estimation procedure for different physiological modes of actions.
- Develop skills for identifying likely physiological modes of actions and evaluating the goodness-of-fit.

Reads:
For an introduction to the use of the standard DEB model in ecotoxicological analyses, see: Jager et al. https://doi.org/10.1016/j.ecolmodel.2022.110187

The experiment with *Daphnia magna* and silver nanoparticles has been published by Mackevica et al. https://doi.org/10.1016/j.aquatox.2015.01.023

Download zip folder with files for working

Participant discussion topics

Alphabetically by first name

Alejandra Ortiz Duran

DEB-Storage Model: An Extension of the DEB Framework

I aim to apply the DEBtool to calibrate a modified DEB model that accounts for seasonal food scarcity in North Sea plaice (*Pleuronectes platessa*). While the standard DEB model offers a framework to describe energy acquisition and allocation, the model gets into trouble once the reserves are depleted, something that does not align with empirical observations in plaice, which can survive up to 300 days without feeding and without shrinking. Some existing DEB modifications suggest that energy may be redirected from reproductive tissues to cover maintenance costs during food shortage. However, in plaice, empirical data indicate that individuals can survive such periods without compromising reproductive output, suggesting a more complex physiological response.

To address this gap, I am working on an extended model, the DEB-Storage model, which introduces a separate “energy storage bucket,” distinct from the standard reserve compartment (parallel to the Reproduction buffer bucket). This buffer allows individuals to survive extended periods of food scarcity while maintaining core physiological functions and reproductive investment. This modification is particularly relevant for species like plaice, which build up energy reserves during the summer and spawn in late winter, implying a seasonal storage strategy that is not well captured by existing DEB formulations.

Problems: I have access to individual-level data, including total body weight, gonad weight, length, spawning period, and intra-seasonal variability. However, this dataset is institutionally restricted and cannot be made publicly available (e.g., via GitHub). I have calibrated the model using other tools (Mathematica), but I have not yet used the standard DEB calibration routines because I have not succeeded in incorporating seasonal variability in food availability into the model structure. Therefore, my main challenges include the technical integration of seasonal forcing into the calibration process. I would also appreciate feedback on this approach.

Alex Coverley

Background/ anticipated issues:

I'm interested in the energetic trade-offs in acclimating to thermal variability for the temperate dung beetle *Onthophagus taurus*.
I acclimated eighteen beetles to a high fluctuation treatment of 20°C ± 12°C with a 12:12 L:D cycle and maintained the rest at 20°C ± 2°C. After two weeks, beetle behaviour was recorded for 24 hours. Metabolic rate was assayed at 20 °C, 25 °C, and 30 °C. Locomotive behaviour was recorded during the trials. I found greater activity in beetles acclimated to 20°C ± 12°C. With different individuals, I assayed carbohydrate and lipid following acclimation and therefore can estimate available reserves.

I want to use biophysical modelling to determine how energy expenditure over the summer period differs between acclimation treatments. Energy expenditure is much higher during flight. The minimum flight temperature differs between treatments and by mass. Although flight increases energy expenditure, it also increases foraging speed and resource acquisition. While the assays done in the lab can be used to determine energetic cost, they do not consider resource acquisition and how the differences in locomotive preferences under acclimation affect the overall energy budget of the organism.

I'm making a DEB model in NicheMapR that incorporates estimates of reserves, metabolic rate, mass, lower limit of the temperature at which flight occurs, and metabolic rate during flight. I'm specifically looking at adult beetles and not growth.

What I would like help with:

Some of the parameters on the AmP database seem to be off. (e.g. P_m, P_Am, Kap). I'm attempting to correct them using experimental data and values from the literature. I'd like to discuss the assumptions in the model and see if there are ways to improve upon my code. I'd also like some guidance on how to better match resource availability and behaviour. Dung is a strange resource. Dung pats are large, and beetles will stay at them for relatively long periods of time. I've not yet begun to tackle this issue.

Alex Robinson

I am working with Ellie Grove (also UKCEH but unable to attend this course) on the sublethal effects of pesticides on the moth *Mamestra brassicae*.

Lepidoptera represent an ideal group for ecotoxicological study as they are convenient to rear of artificial diet and have radically different life stages. As the adults and larvae are adapted to contrasting physiological roles and feeding strategies they express very different suites of xenometabolic pathways. Since they are genetically identical yet with widely different transcriptomes, by observing differences in chemical sensitivity between the life stages they make an ideal subject for identifying processes responsible for detoxification.

For the current study we have exposed larvae from hatching to pupation to concentration series of 6 commonly used agrochemicals (cypermethrin, imidacloprid, acetamiprid, pyraclostrobin, tebuconazole and azoxystrobin). Survival and weights were measured at 1, 14, 18, 21, 25 and 28 days along with the time to pupation, the eventual pupation weight, any pupation failure, the emergence date and the sex. The chemicals were chosen to represent commonly used examples of 2 major classes of fungicide and 2 of insecticides.

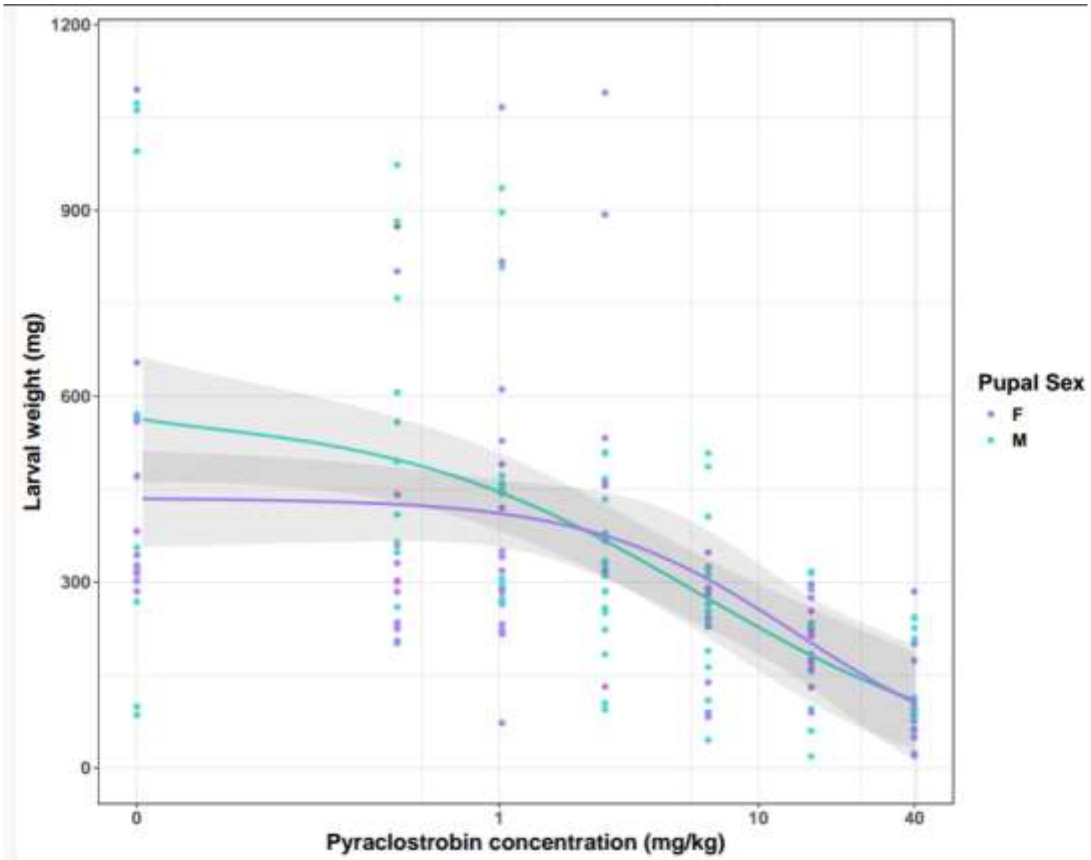
Strong dose dependence has been seen, with higher doses experiencing delayed pupation. In the case of the neonicotinoid insecticides, very high rates of pupation failure were seen at higher doses. Males and females also appear to respond differently.

This work is being carried out in conjunction with the Butterfly Conservation Trust and is linked to the EU SYBERAC project. In both cases, obtaining reliable estimates of the lowest effect concentration would be very valuable and are difficult to obtain using traditional techniques.

I hope to be able to use DEB to distinguish between the different responses seen according to chemical. In the case of the azoxystrobin, the larvae appear to display a competent metabolic response. Previous work in our group has observed that after initial transcriptomic chaos (1-4 hrs) a couple of key genes are heavily upregulated, but otherwise the situation stabilises. In response to cypermethrin, there is no such detoxification response. Large scale RNA sequencing is a powerful tool, but expensive and unwieldy. DEB could not only identify different physiological modes of action but also assign estimates of the energetic costs of exposures to sublethal concentrations.

<u>Difficulties</u>

- Data collection very time consuming, so only a limited number of time points.
- Pulsed exposures difficult
- Exposure route hard to quantify – both contact and dietary
- Small larvae difficult to handle so no weights before day 14
- Is it fair to treat eggs as identical?
- Exponential growth means small temporal shifts lead to large weight differences. This is the biggest difficulty with traditional Dose – Response analysis, but I hope DEB will be much better suited to it! See graph below…



Anamarija Zagar

I would like to learn more about DEB modeling and gain hands-on experience for my research project that focuses on studying the effects of environmental factors (humidity and temperature) on the ecophysiology and life history responses of ectotherms (beetles, spiders and lizards) across a fog-moisture gradient in the Namib Desert. In this course, I will focus on building a DEB model for the Namib day gecko, *Rhoptropus afer,* in an attempt to understand the gecko's life history responses under varying availability of water and temperature in its habitat.

Anna Sulc

My work focuses on integrating a protected marine mammal (the *Northern Fur Seal, NFS*) predator into a climate-enhanced, age-structured multi-species stock assessment model (CEATTLE, Holsman et. al, 2016).

The CEATTLE model includes commercially important groundfish species, Walleye pollock (*Gadus chalcogrammus*), Pacific Cod (*Gadus macrocephalus*), Arrowtooth Flounder (*Atheresthes stomas*) and Pacific Halibut (*Hippoglossus stenolepis*), from the Eastern Bering Sea (EBS). Predator-prey dynamics are modeled through a bioenergetic module in CEATTLE considering the Wisconsin bioenergetic approach and are informed based on diet data of each groundfish species. NFS are an apex predator in the EBS and primarily prey on Walleye Pollock. However, their breeding season coincides with the pollock fishery resulting in competition between breeding NFS and fishing activity. As a culturally important marine mammal for the St. Paul indigenous community and a protected marine mammal, it is important to assess the impacts of population changes of Walleye pollock on NFS. For this reason, my project aims at incorporating the NFS population dynamics into CEATTLE.

Specifically, I will be developing a DEB model to first account for the bioenergetics of individuals in the population and then scaling up these dynamics to the population level. Given that the NFS population is primarily driven by pup survival, capturing the processes surrounding lactating female reserves and weaning will be important.

Anticipated Difficulties and Questions:

- Moving from individual DEB to population model?
- Setting cut offs for lactating female fitness and pup survival?

Caroline Fleming Ianniello

I study the temperate coral *Astrangia poculata*. *A. poculata* exhibits a facultative symbiosis; existing with (symbiotic) or relatively without (aposymbiotic) its endosymbionts. This provides a tractable opportunity to disentangle the contributions of auto and heterotrophy to coral growth and metabolism. The overarching aim of my research is to leverage a laboratory experiment to parameterize a DEB model for both symbiotic and aposymbiotic *A. poculata* in the Add My Pet (AmP) framework. In a 90-day experiment, I exposed host (aposymbiotic) and holobiont (symbiotic) *A. poculata* to different light and food levels. At regular intervals, we collected physiological metrics including polyp growth, grazing rate, biomass, lipid, protein, and chlorophyll content. Experimental results show that *A. poculata* biomass is more sensitive to changes in light versus food level; higher light levels correspond to higher biomass and lipid levels, especially in symbiotic corals. Comparisons of AmP parameter estimates for aposymbiotic vs. symbiotic *A. poculata* will provide critical insights into the energetics of symbiosis.

I have begun this process by adapting the AmP entry for the fairy shrimp *Streptocephalus vitreus*. I will present my preliminary results in a poster at the conference, but want to learn how to include more data (feeding rate, respiration rate, lipid, protein, and carbohydrate levels) and generate an independent AmP entry for *Astrangia poculata*. I am expecting a big challenge will be incorporating (or dealing) with symbiosis in the AmP framework. I am doing this work in collaboration with Drs. Randi Rotjan, Erik Muller, and Roger Nisbet, who have suggested that I generate a separate AmP entry for symbiotic versus aposymbiotic *Asrtangia.* I know that incorporating symbiosis has been a longer-range discussion, and would love to discuss whether and how this is possible. This is the final chapter of my dissertation, and I am hoping to make significant progress on it during my time in Greece.

Angel Ceballos-Ramirez

My PhD project looked into adapting OECD standardized tests into a high throughput setting and seeing if they can be validated using DEB modelling and theory, and given the amount of data generated, can extrapolations be made between chemicals and species?

Can the HT methodology predict lethal and sublethal endpoints using the full DEB model? What adjustments would the data need to go through to pass from a DEBkiss context into a full DEB Model one?

Christine Verhille

For the thematic course, I will work on parameterizing a DEB model for the salmonfly (*Pteronarcys californica*), which belongs to the order Plecoptera (stoneflies). My longer-term plans are to apply DEB models for salmonflies, pallid sturgeon, and brown trout to address questions about phenotypic plasticity and inter-individual variation. The salmonfly is a large-bodied aquatic insect that spends 2–4 years as an aquatic nymph undergoing 12-20 molts before emerging as a short-lived terrestrial adult. Due to the complex life history of the salmonfly, this model will require an h-model typified extension, specifically the hep extension to accommodate the hemimetabolous life history (i.e., with incomplete metamorphosis) of the salmonfly. Problems I anticipate as I parameterize this DEB model include: 1) My limited understanding of metabolic acceleration and how to apply knowledge about this species to the variables for metabolic acceleration; 2) whether sufficient data is available to parameterize this model with reasonable completeness; 3) this problem may be compounded by a lack of evolutionarily close species within the AmP collection. No species within the order Plecoptera are included in the AmP collection and the closest phylogenetic relative included belongs to the order Orthoptera (locusts), which likely diverged from Plecoptera ancestors >250 million years ago.

Clarisa Marek Ortiz

The goal of my doctoral thesis is to evaluate the single and combined effects of chlorothalonil (fungicide) and heat waves on Chironomus xanthus, a chironomid native to Argentina and Brazil that is used as a bioindicator of water quality. For this purpose, I will conduct laboratory bioassays where individuals will be exposed to these stressors throughout their life cycle and the following generations. Finally, I want to apply the DEB model (specifically the DEBtox extension) to the obtained experimental results to simulate other exposure scenarios and estimate their effects. Among the challenges of applying the DEB model to my research topic I find the following:

- Estimate the parameters of the life cycle stages of the species of interest, which present significant differences in their morphology, feeding and habitat (eggs, larvae and pupae are freshwater, while adults are flying terrestrial).

- Estimate the maintenance cost associated with osmotic equilibrium.

- Model the simulated heat waves in the bioassays, which will occur at specific times in the life cycle and will consist of a thermal ramp-up to the desired temperature, a period of constant temperature, and then a thermal ramp-down to the control temperature.

- Include data from several generations in the model to evaluate the transgenerational effect of the stressors.

David Deslauriers

Understanding the effects of global change, including changes in water temperature, oxygen availability, and pH, on commercially important marine species is crucial to improve current stock assessment practices. After more than 30 years under fishing moratorium, a massive recruitment of redfish (*Sebastes* spp.) was observed in 2011–2013 in the Gulf of St. Lawrence (GSL), Quebec, Canada. Still, little is known about their metabolic and thermal physiology and so it is difficult to predict how they will respond to rapidly changing conditions, including the alarming decreases in dissolved oxygen currently being observed in the deep channels of the GSL. The GSL is experiencing rapid changes in temperature and oxygen availability caused by a change in water current proportions (Gulf stream vs. Labrador current) and enhanced bacterial metabolic activity. Three laboratory experiments have been conducted to better understand Redfish physiology under global change. First off, we quantified the effect of four acclimatation temperatures (2.5, 5.0, 7.5 and 10.0 °C) combined with two pH levels (7.35 and 7.75) on standard and maximum metabolic rates (SMR-MMR), aerobic scope (AS), and hypoxia tolerance (O_2crit), food consumption and growth in redfish (n = 64) that were exposed to these conditions for 7 months. We observed that higher acclimation temperatures, within the range of temperatures in our study, translated into higher standard and maximum metabolic rates and aerobic scope. We also found that hypoxia tolerance was higher for fish acclimated to lower temperatures (2.5 and 5.0°C). This suggests that redfish will have increasing difficulty coping with their changing habitats under the rapid rise of both hypoxia and temperature currently occurring in the GSL. These results indicate that while GSL redfish could still live comfortably at temperatures up to 10 °C, there may be important effects to consider on their long-term energy requirements due to increased maintenance costs. Secondly, we exposed Redfish to 8 different dissolved oxygen levels (95, 85, 75, 65, 55, 45, 35, 25 % Air sat.) for a period of six months. Once again SMR, MMR, AS, O_2crit, food consumption and growth were quantified. Because Redfish is a commercially important species currently under moratorium, we want to use DEB to understand the effect that environmental factors will have on energy allocation for growth and reproduction of that species. We are observing a difference in length at maturity since the new cohort has appeared, making individuals smaller than they used to be. We want to use DEB to better understand if the cause of that change is density-dependent or environmentally driven.

Specific questions

– how to include the effects of pH and hypoxia in DEB
– how to include prey (e.g., northern shrimp) and predator (redfish) energy densities
– how to include environmental thresholds (e.g., CTM data) using parameters T_{AL}, T_L, T_{AH}, and T_H

- How to test to see if differences exist between parameters (i.e., overlapping confidence intervals) estimated for *S. fasciatus* and *S. mentella*, as *S. fasciatus* is used in laboratory studies as a proxy for *S. mentella*.
- How to track O_2 fluxes across pools and throughout ontogeny

Dana Baskir

The goal of my research is to investigate the influence of pesticides on pest control ecosystem service provision. The chosen service providing unit is the pirate bug (*Orius laevigatus*), i.e., the predator, preying on thrips, i.e., the pest species, and using pollen as an alternative food source. Development and reproduction of pirate bugs are affected by the type of diet they consume. When prey and pollen are provided, pirate bugs tend to consume both and have similar survival, development and fecundity as on exclusively prey diet. However, fully pollen diets have been shown to prolong developmental times, decrease survival and reduce fecundity. I would like to implement these different food sources as part of the *O. laevigatus* DEB model in order to study how the presence and absence of prey affects predator abundance throughout multiple years when pollen is available outside hibernation periods. I would also like to compare the pirate bug population dynamics produced by different models that are part of DEBtool, since I am planning to compare predator-prey dynamics produced by an agent-based model and partial differential equations in my future research.

David Schneider

Use of DEB Models in Ecotox Research for Pesticide Assessment

In my daily work on the approval of plant protection products, I want to use DEB modeling to simulate and predict the effects of pesticides on non-target animals (NTAs). These models can help us investigate and better understand the sublethal effects of xenobiotics on individual organisms (behavioural changes etc.) and potentially understand how these effects can impact entire insect populations. By considering the energetic resources of organisms, we can better assess the ecological risks associated with the use of pesticides. As the demand for species extrapolation by regulatory bodies steadily increases, modeling approaches like DEB modeling provide an effective way to address these questions in a structured and sophisticated manner. This aligns with the growing acceptance of modeling approaches (such as GUTS) by regulatory authorities for the approval or re-registration of new pesticides.

An important point will be to discuss the challenges that arise when applying DEB models. For example, it may be difficult to validate the models for different species and life stages. Additionally, accounting for varying environmental conditions and their influence on model parameters is an important topic. Possible further questions are: How can we reduce uncertainties in the models to make reliable predictions? What data do we need to properly calibrate and validate the models? And, more related to my work, how can we incorporate the results of DEB models into the decision-making processes for the approval of plant protection products? (including necessary advocacy)

I hope that through this discussion, we can gather valuable ideas and insights that will support my work and contribute to the development of safe pesticide strategies.

Eline Le Moan

My PhD is about how scallops retain a toxin that cause amnesic shellfish poisoning. The retention depends on the species, and I mostly work with king scallop, variegated scallop and Chilean scallop. I'm using DEB theory to compare species in terms of physiology, to help us understand these differences in how quickly they depurate the toxin and the link with environmental conditions. I used two approaches within DEB theory: I compared the scallop species based on their DEB parameters using individual and multi-species parameter estimation, and I developed a "toxic module" linked to the DEB model to assess the contamination and decontamination dynamics. I'd like to discuss about this model, as I think we could improve the definition of toxin assimilation, but there is not much data on this process. I'd also like to discuss about inter-individual variability and how to implement it.

However, for the DEB school practise I'd like to continue a comparison of anchovy species in upwelling regions that I started before my PhD. I 'd like to realise the parameter estimations and start applying the multi-species parameter estimation as for scallops. So, I'd like to discuss about the limits encountered in order to improve this second study.

Elisa Donati

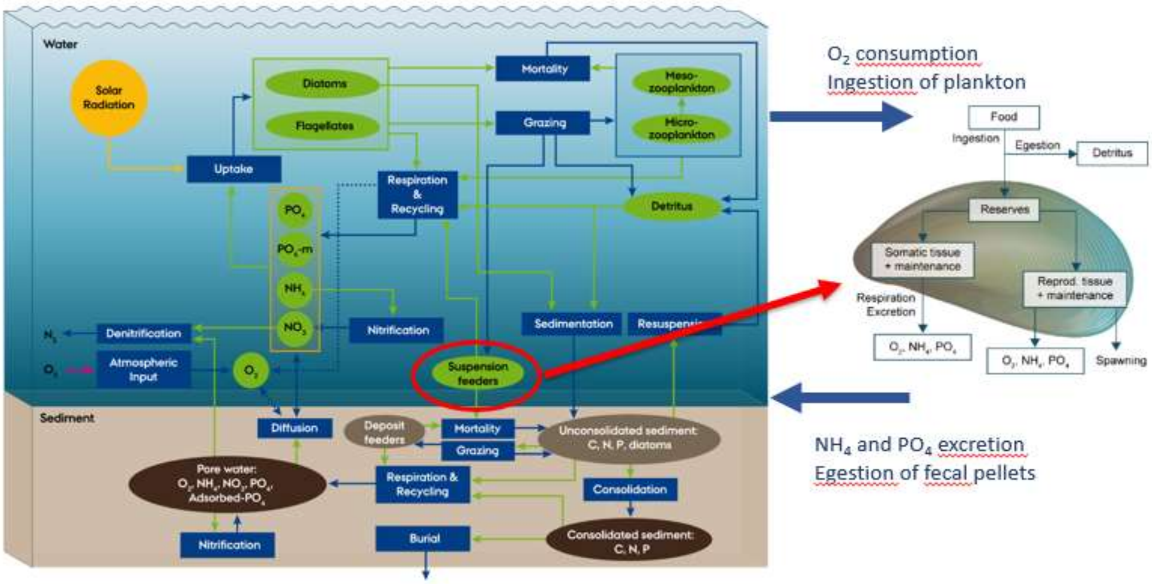
I am a biologist in the third year of my PhD. Although new to the topic, I have applied Dynamic Energy Budget (DEB) Theory to develop a novel population agent-based model (ABM) in Julia, focusing on European sardine (Sardina pilchardus) and anchovy (Engraulis encrasicolus) populations in the Adriatic Sea. In this model, individual-level bioenergetics (growth and reproduction) are governed by DEB Theory. The aim of my research is to enhance our capacity for ecological forecasting by integrating individual physiological processes and behavioural traits into population-level simulations. The model can support evolutionary scenarios, helping us understand how and why the life-history traits of sardines and anchovies are shifting in response to climate change and anthropogenic pressures.

I started with the Add-my-Pet standard parameter sets but encountered challenges when trying to reproduce realistic life-history patterns at the population level. This was particularly true for sardines, where reparametrization was necessary to improve reproductive rates. One of the major challenge was scaling individual-level processes to population dynamics, especially considering the juvenile- driven population cycles observed in these species and avoid excessive starvation.

Sardines and anchovies are also unique since they are multiple-batch spawners — they releasie several batches of eggs during a single reproductive season, with gonadal mass increasing as the season progresses. Through this edition of the DEB school I would like to explore how to adapt parametrization routine to these biological particularities, and refine my model accordingly.

Gaia Grieco

In the second year of my PhD project in mussel reef restoration, in particular, the blue mussel, *Mytilus edulis*. I plan to couple a DEB model to a biogeochemical mussel growth model to estimate previously chosen suitable sites for mussel growth and evaluate the provided benefits of mussel restoration. The idea is to do this by estimating filtration rates to gauge the changes in water clarity.



Since blue mussels are already well described in DEB, I think the first challenge will be to ensure I fully understand what is already there. After that, getting comfortable with the setup in a little more than a week will probably also prove challenging.
My question is: Are there any considerations to be made when coupling a DEB model?

Fabio Vanucchi

Can knowing body size help in the conservation of a species?
Several threatened species have action plans developed with the goal of conserving the species, both from demographic and genetic perspectives. These plans are often complemented by - or even based on - Population Viability Analyses (PVA), which are tailored population models that incorporate threats and potential management actions. PVAs provide future demographic and genetic projections and evaluate the impact of threats and conservation efforts.
These population models are typically based on processes described by subject-matter experts. The key parameters of such models (vital rates, demographic and genetic structure, etc.) are obtained through field observations and expert opinion.

However, almost nothing regarding ontogenetic dynamics is incorporated into these models. In this regard, our central question is: "How can DEB theory provide useful insights for population models aimed at conservation?"
This general question can unfold into several more specific ones:
- Can DEB theory help estimate natural mortality rates?

- How do changes (and fluctuations) in environmental temperature and food availability influence reproduction?
- Can we estimate a species' carrying capacity using energetic arguments?
- Can ex situ population parameters be used to estimate parameters in wild populations?

In our specific case, we aim to use DEB theory to analyze the effects of food deprivation on the reproductive dynamics of a threatened Brazilian parrot. The red-spectacled amazon (Amazona pretrei) is an endemic bird of southern Brazil that is particularly dependent on Araucaria angustifolia forests, from which it obtains its main food source in autumn and winter: the pinhão (the araucaria seed). The search for areas with higher pinhão availability drives its seasonal movements and the formation of large flocks. A. angustifolia produces pinhões annually, but with cyclical and irregular variation in quantity, alternating between high and low yield years (usually every 2 to 4 years). This production is synchronized among trees in the same region, resulting in years of widespread abundance or scarcity. In addition, ongoing loss of araucaria forest remnants and increasing commercialization of pinhão have led to a significant reduction in resource availability for the red-spectacled amazon.
What is the impact of pinhão supply dynamics on the ontogeny and population dynamics of the red-spectacled amazon?

Gitai Yahel

My name is Gitai Yahel. I am a marine biologist, and my group studies suspension feeders (e.g., sponges, bivalves, and tunicates) and suspension feeding across a broad range of ecological niches in the ocean. A major thrust of our work is the development and application of in situ methodologies that enable us to study undisturbed animals under natural conditions in the field. The more we explore aspects of the metabolism of pumping suspension feeders, quantifying rates of water processing, oxygen uptake, and nutrient excretion, the more confused I become regarding the interpretation of our findings, especially since our field data often contrast with published data. For example, the respiration rates we measure in the field are often much higher than published data or data we measure using traditional closed chamber respirometry. Similarly, while we see a classic thermal response in close chambers respirometers, we see very different, sometimes even the opposite, when we use direct measurements in the lab or the field. Since I lack a formal background in metabolic modeling, I took the advice of a colleague to enroll in this course to educate myself and learn more about the basic concepts of the DEB.
My main goal in attending the course is to learn the language, terminology, and concepts of metabolic molding to gain a better understanding of how and where the DEB theory and practices can assist me and my students in better interpreting our experimental data and placing it in a more general and cohesive context. If I understand correctly, contrasting empirical rates (respirations, food uptake) with model predictions within the DEB framework is particularly challenging, and I will focus during the course on learning how to do that.

Hans Schepers

I support Maurice Glucksman from Thalassa ltd (UK) with modelling the value of innovations in fish farming in the context of the EU project Cure4Aqua (27. Thalassa Limited (THL) | Cure4Aqua) where DEB models may well be the physiological core of the economic model. This is done in close contact with HCMR with Sea bass and Sea Bream as likely species of interest.
Next I would like to see how a "Digital Twin" decision support tool can be developed for fish farmers, fish feed experts, that would also link operational decisions to (among others) the physiological state of the Fish. This would build on my prior experience of developing and implementing such Digital Twins for greenhouse Tomato Growers. The crop physiological model for tomatoes were centered around sink strengths of fruits, resulting an emerging allocation of energy (assimilate) fluxes, which is an interesting topic to discuss in the context of animal DEB models! Finally, I studied biology 35 years ago, and published one article on eco-physiological toxicant accumulation (Dynamic energy budgets affect kinetics of xenobiotics in the marine mussel Mytilus edulis - ScienceDirect)

Jake Britnell

My research focuses on understanding the processes that limit population density. I aim to model organismal requirements—what I refer to as “ecological demand”—and match them with the “ecological supply” of environmental resources across landscapes. My earlier work used correlative approaches, combining physiological markers (e.g. diet, endocrinology, microbiome, and nemabiome) and correlative ENMs, particularly in species like the Cape mountain zebra and other large mammals. Over time, I grew disillusioned with these methods and, inspired by the work of Professor Michael Kearney, shifted to fully mechanistic models (which I plan to use in future projects within my fellowship). I now use biophysical and Dynamic Energy Budget (DEB) models, primarily through NicheMapR.

I plan to apply DEB models to assess how climate change will affect the viability of large herbivores in South Africa's fenced protected areas. These reserves serve as natural experiments—distinct ecological islands across gradients of rainfall and food availability. I am currently modelling energetic constraints across seasons, with case studies including springbok colour morphs (*Antidorcas marsupailis*) (to assess how pelage colour affects seasonal energetic bottlenecks) and African elephants (*Loxodonta africana*) in both open and forested environments.

Concerns:

My main concern is the data required to parameterise DEB models. Due to the size of these mammals, invasive validation methods (e.g. metabolic chambers) are often unfeasible. I am also grappling with how to integrate variable food availability. While I understand this can be represented through food density, I'm unsure how best to implement it—whether through fieldwork per reserve and developing population-specific DEB models or through modelled estimates of grass availability and the same DEB model across the entire species range?

Jason Adams Hale

Plectropomus oligacanthus (Epinephelidae), the highfin coralgrouper, among the least studied of coralgroupers in the Indo-Pacific. They are predators of their habitat, which includes coral reef channels and drop-offs from 4 to 40 m depth, and when observed, they are seen in groups of 2 or 3 individuals.

All online references refer to a paucity of biological data for this species. This may be due to naturally lower abundance than other *Plectropomus* species, as well as higher abundance of *Plextropomus* species which support commercial and sport fishing. As they are relatively less abundant, *P. oligacanthus* seems not to support an active fishery, but is nonetheless seen in fish markets. This suggests a need for some assessment to manage this uncommon species. Further, the species may be sensitive to habitat quality (high relief coral reef), and a better understanding of the species may contribute to conservation of the habitat.

The AmP Species list includes models for 5 species of *Plectropomus*, and does not include *P. oligacanthus*. All of the DEB models for *Plectropomus* species are "abj" type. It is likely that this species is a protogynous hermaphrodite, and a relationship between age, sex, and size is expected. Data completeness for the existing 5 models is 2.5, and by most accounts, the basic biology of *P. oligacanthus* is less well studied, so I expect the need to borrow parameters from other species' models.

The IUCN Red List page for this species (https://www.iucnredlist.org/species/132776/100469016) cites an unpublished comparison with *P. leopardus*, the leopard coralgrouper (H. Choat pers. comm. 2016).

My proposal to use *P. oligacanthus* as a study animal will be to edit the existing DEB model for *P. leopardus*, and then propose parameters using as much ecological information and as can be found in literature and observations of *P. oligacanthus*, and other members of *Plectropomus* genus that may share characteristics (e.g. habitat, geographic distribution, prey, size, etc.).

Katerina Pitsika

In my research, I aim to apply DEB theory to model the physiological energetics of the marine calanoid copepod *Acartia tonsa*. This species is ecologically and commercially important, but lacks a DEB model in the database. My goal is to quantify how *A. tonsa* allocates energy across life stages—especially under varying environmental conditions—by integrating empirical data on respiration, ingestion, egg production, and growth. The model will help predict organismal responses to changes in temperature and food availability, with potential applications in ecosystem modeling.

One challenge I anticipate is the limited availability of stage-specific data, especially for the earlier naupliar stages, which may affect parameter estimation accuracy. Additionally, *A. tonsa* does not store lipids in the same way as some other copepods, raising questions about how to best represent reserve dynamics in the model. I would be interested in hearing how others have handled species-specific deviations from standard DEB assumptions, and what strategies can be used to validate DEB models when field data are sparse or variable.

Kevan Rastello

I am working on the Mountain pine beetle (MPB) (*Dendroctonus ponderosae*), a major forest insect pest responsible for the destruction of millions of hectares of trees in western North America. My goal is to apply the DEB to study how temperature influences the metabolism of the MPB. One key aspect of MPB overwintering biology is the synthesis of cryoprotectants (glycerol), which allow the beetle to survive extremely low temperatures. This physiological adaptation is assumed to be energetically costly. I plan to model the cryoprotection mechanism in the DEB framework as an increase in somatic maintenance during cold periods.

As winters become milder, I hypothesize that the beetle will need to allocate less energy toward cold resistance. Instead, this energy could be redirected to growth and may also influence reproduction. My objective is to parameterize a hex DEB model for the MPB using data from the literature and data collected by my collaborators, which quantify how much energy is accumulated to cryoprotection during winter as a function of temperature. I would like to take this opportunity to mention some challenges I am currently facing.

First, the MPB larval growth of structure is continuous but the increase in physical size occurs periodically through moulting. I would have to make sure that I correctly model this as a discrete process. One starting point can be this paper.

Second, my data come from a lot of different populations and across a wide range of conditions. I am concerned that using different combination of these datasets could lead to various estimate of the parameters. In this context, how can I decide one set of data to use? Do you have any advice on how to handle this variability and ensure consistent and reliable model calibration?

Third, one of the main questions I have relate to the MPB lifespan. The MPB is univoltine and its lifespan is about 1 year. However, my dataset does not cover this scale. Instead, I have individuals reared under laboratory conditions, mostly at constant temperatures. Under these conditions, the MPB lifespan vary roughly between 40 to 100 days. I am wondering whether I can reliably estimate parameters using the laboratory-derived data, given the difference with the beetle's life cycle in the field.

Finally, one central key aspect of my work is to integrate the cryoprotection data in my DEB model. How can I best represent cryoprotectant energy allocation within the DEB formalism given the data that I have? Should this be modeled as a distinct energy flux, or as a modification to existing maintenance costs?

Killian Chary

Modelling Aquaculture (Eco)Systems

In aquaculture, aquatic animals (e.g., fish, shrimp, shellfish) and plants are cultivated in a variety of environments—including lakes, rivers, oceans, and ponds—where environmental conditions may be either controlled or natural. In some production systems, animals are fed commercial compound feed, whereas in others, they rely primarily on naturally available resources such as plankton, macroinvertebrates, or insects. Environmental factors such as temperature and food availability are often variable over time, which directly influences key metabolic processes, including feed intake and growth.

Accurately predicting feed intake, growth rates, and other metabolic variables is critical for aquaculture management, as these factors drive both production costs (through feed use) and the duration of the production cycle (i.e., time to harvest). In my research, I use Dynamic Energy Budget (DEB) models to study aquaculture systems and ecosystems for a range of purposes: estimating farm productivity under diverse and variable environmental conditions; evaluating the feasibility of co-culturing species with complementary feeding strategies (based on energy transfer between organisms); and quantifying environmental impacts due to nutrient emissions from fish farms.

At CIRAD, my research now focuses on multi-species aquaculture systems in tropical environments. This new application context raises several challenges:

- **Limited species-specific data**: For most tropical species farmed in Asia and Africa—except for a few key commercial ones—empirical data are scarce. How can DEB models be parameterized in data-poor contexts?
- **Beyond energy flows**: While DEB models are primarily based on energy budgets, living organisms also require balanced macro- and micronutrient intake to support growth and maintenance. How can DEB frameworks be extended or integrated with nutrient-based approaches to better reflect metabolic needs?
- **Parameter relevance for farmed vs. wild populations**: Although the Add-my-Pet database provides a wealth of DEB parameters, these are mostly derived from wild populations, which may differ genetically and phenotypically from their farmed counterparts. Can we identify which DEB parameters are most likely to diverge between wild and farmed populations, and how should these differences be accounted for?
- **Effect of the environment**: Aquaculture animals are directly affected by water quality conditions, including temperature, O2 levels, pH, NH3 concentrations. However, standard DEB models only include two forcings, temperature and food availaibility, therefore how to properly model fish metabolism with DEB accounting for the effect of these other environmental variables?

Lauren Albert

Energetic stress from the environment combines with parasite-driven, internal starvation to virulently depress host life history traits. This hypothesis starts with links between availability of environmental resources to allocation of internal energy within hosts to growth and reproduction. Low resource supply causes energetic stress (‘external starvation') that depresses life history traits of hosts. These life history traits additionally respond to infection. Parasites that rely on hosts for resources can directly steal or manipulate the host energy toward growth and reproduction. I hypothesize that through this theft, ‘internal starvation' inflicts virulence that exacerbates effects of external starvation. Therefore, the external supply of resources plus internal starvation can modify the suite of interconnected life history traits of a host.
I study this phenomenon in a planktonic host-parasite system. The host (***Daphnia dentifera***) becomes infected by consuming spores of a virulent fungus while foraging on phytoplankton. I have conducted assays rearing hosts along a resource supply gradient to measure effects of external resource and fungal spore density on life history traits. I measured host age and size at maturation, number and size of offspring, and time of death. To synthesize these results mechanistically, I aim to construct a dynamic energy budget model that explicitly tracks within-host energy depletion by parasites. Additionally, I aim to understand how host energetics simultaneously constrain within-host parasite production. By leveraging an energetic framework, I hope to connect how both external and internal starvation explain why infection virulently depresses traits of hosts while subsequently imposing limits on parasite production.
Some anticipated challenges:

- How might I incorporate parasite population growth within the host in the model? What limitations are imposed to parasite growth because of the internal starvation?
- How will the resource supply gradient change assumptions and processes of modeling?
- What inferences can I make by parameterizing a model for different clonal genotypes of the host? How might these differences scale to the population level?

Lisa Gollot

Applying DEB-TKTD to Pesticide Mixture Toxicity in Soil Invertebrates
In my research, I aim to apply the DEB-TKTD framework to investigate the combined effects of two persitant pesticides—imidacloprid and epoxiconazole—on the earthworm *Aporrectodea caliginosa*, a key species in temperate agricultural soils. After characterizing the toxicokinetics of both compounds, we have designed a detailed reproduction test following an adapted OECD 222 protocol, including both single-compound and mixture exposures. This dataset will provide the basis for calibrating a DEB-TKTD model to quantify how pesticide exposure alters energy allocation, cocoon production, and juvenile development.

One of the core challenges we face is how to mechanistically represent the observed synergy between the two compounds. Should this interaction be accounted for at the TK level (e.g., one compound affecting the internal concentration of the other), or is it better represented within the TD component—through combined effects on the stress function or on allocation rules in the DEB model? This question is central to accurately modeling mixture effects and capturing the physiological mode of action.

I would welcome feedback on how others have handled such interactions in mixture modeling, and whether there are best practices or criteria for deciding where to place the interaction within a DEB-TKTD framework. Ultimately, this model will feed into an individual-based model to explore long-term population impacts, so preserving mechanistic clarity is essential.

Louisa Diele-Viegas

Research Description: I aim to apply DEB models to understand how energy acquisition and allocation in frogs are affected by temperature variation and Bd infection. By parameterizing DEB models with empirical data on thermal performance and infection status, I will simulate energy budgets under different environmental conditions to assess how disease and climate interact to constrain individual fitness and population viability. This approach will explore how infected and uninfected individuals differ in energy allocated to growth, maintenance, and reproduction across thermal gradients, and how this influences survival and behavior in the wild. One anticipated challenge is parameter estimation, especially for species with limited physiological or life-history data. Accurately representing host-pathogen interactions within the DEB framework also requires careful modeling of Bd-induced reductions in assimilation and increased maintenance costs. I am also exploring how to scale individual-level DEB outputs to population and spatial scales using mechanistic niche models, which requires harmonizing temporal and spatial resolution across datasets. Ultimately, my goal is to integrate DEB models into broader ecological forecasting tools to better inform conservation strategies for amphibians under threat from both climate change and infectious disease.

Luis Miguel Senzano Castro

Leptodactylus podicipinus (Leptodactylidae) is a small, ground-dwelling frog widely distributed in South America, known for its year-round reproductive activity, even in regions with strongly seasonal climates. The species relies on foam nests built in shallow aquatic habitats, where females often engage in active parental care, attending and guiding tadpoles until metamorphosis. This reproductive strategy, while beneficial for offspring survival, imposes significant energetic demands, particularly on females.

A few studies have highlighted that female *L. podicipinus* investing in egg production and tadpole care experience measurable energetic costs, reflected in body condition, reproductive effort, and thermoregulatory behavioral shifts. Despite this sporadic empirical evidence of energetic trade-offs, there is a lack of mechanistic models that quantitatively explore energy allocation in reproductive budgets, especially under varying environmental stressors.

Our laboratory has been investigating sex- and reproductive state-specific differences in thermal preference, dehydration tolerance, and thermal limits in *L. podicipinus*. While these physiological findings are not mandatory for DEB parameterization, they offer valuable empirical evidence supporting the notion that energy allocation strategies vary according to sex and reproductive condition.

The Dynamic Energy Budget (DEB) theory provides an interesting framework to model these processes, offering a quantitative understanding of how parental care affects individual energy allocation and/or its possible implications under potential climate alterations. By applying DEB modeling to *L. podicipinus*, I intend to explore at least one of the following key aspects: 1) Estimate the energetic consequences of parental care behaviors under different seasons; and/or, 2) Explore how environmental pressures (e.g., elevated temperature and increased dehydration risk under climate change scenarios) modulate these energetic trade-offs.

Maria Rakka

I am a postdoctoral researcher at Dalhousie University (Canada), studying deep-sea benthic ecosystems. My research focuses on deep-sea coral species, and the potential effects of climate change on the communities they form. I am planning to use Dynamic Energy Budget (DEB) models to investigate how ocean warming may affect the growth and reproduction of key coral species that structure rich coral habitats in the Northwest Atlantic Ocean. As colonial organisms, corals exhibit complex morphological changes throughout their life cycle and do not conform to isomorph assumptions, making the standard DEB model unsuitable. While most existing coral DEB models focus on symbiotic, photosynthetic species, the corals I study are non-photosynthetic, which simplifies modeling but introduces other challenges. To my knowledge, current DEB models for V1-morphs have not yet incorporated maturity and reproduction, which I would like to include in my models. I hope that the knowledge and tools provided by this course will help me better understand these models and address these challenges.

Marina Veseli

My main goals for attending DEB School 2025 are to learn how to apply the Dynamic Energy Budget theory to my research, learn how to use DEB models, and to improve/upgrade *Gammarus pulex* existing entry. I intend to use available data for *Gammarus pulex* from literature with focus on their thermal response. The aim is to re-estimate DEB parameters using published data to improve thermal response predictions. I chose *Gammarus pulex* as my target species because I previously conducted an experiment investigating the effects of wastewater pollution and increased temperature on the metabolic response of this species. I also have data on the length of individuals from the same experiment. This is single-point data, meaning I did not track changes over time during the experiment. During the course, I hope to engage with DEB experts at the school to discuss whether and how this type of data can be integrated into a DEB model.

Matthieu Veron

My current project focuses on individual fish robustness as a determinant of population vulnerability to investigate and predict the ability of fish populations to cope with the current environmental challenges. Global change (namely, climate change and anthropogenic pressures) is already restructuring (marine) ecosystems at both local and global scales and there is a need to identify and understand the underlying mechanisms that shape population dynamics in order to predict their resilience and help ensure the sustainability of those ecosystems. In that context, I am developing a new flexible modeling framework that intends to correct the current shortcomings about DEB models. Specifically, the key feature of this new statistical tool are that it can i) incorporate inter-individual variability in parameter estimation through the use of random effects so parameters are not estimated independently but grouped, ii) assimilate different type of data, including genetic data; iii) incorporate uncertainty in the parameter of the DEB models, iv) allow for alternative hypothesis for model structure, and v) estimate the marginal likelihood through either the Frequentist approach or the Bayesian approach. I am planning to use this framework in my next research project and embed it in (eco-evo) population model with spatial structure.

Anticipated difficulties and question:

- Scaling up the inter-individual model to population model
- Integrating the eco-evolution in the DEB parameters

Suncana Gecek

I am a researcher with basic DEB modeling experience, looking to deepen my expertise in life-cycle modeling of aquatic organisms. My current focus is on*Perna canaliculus*, one of the key species in New Zealand aquaculture. I am particularly interested in extending the DEB model to the family level, building on evidence of inter-population and inter-familial differences in growth, biometry, respiration, and ingestion/fecation.

I have previously parametrized a DEB model for *P. canaliculus*, but parts of the code became non-functional following a recent DEBTool update. Through the DEB School, I hope to recover and refine this model and adapt it for selectively bred family lines. I also aim to develop and integrate a plastic ingestion module to assess the sub-lethal effects of plastic pollution on energy budgets and life-history traits. Additionally, I am interested in using DEB theory to evaluate the broader impacts of ecotoxicants.

The DEB School's combination of theoretical depth and practical training in parameter estimation (AmP procedures) is especially appealing. Collaborating with experienced DEB scientists will be invaluable for strengthening my modeling skills and applying DEB theory to address ecological and aquaculture-related questions.

Tasos Limnios

I am a Biologist with a MSc in "Ecology & Conservation of Biodiversity". I am currently a 2nd year PhD student (Doctoral Programme in Biodiversity, Genetics and Evolution) with a 4-year FCT scholarship (FCT Grant Nr. 2023.04021.BD) at BIOPOLIS-CIBIO, University of Porto, investigating the synergistic effects of climate change and glyphosate on wall lizards.
The main hypothesis of my PhD is that climate change and glyphosate act synergistically and can potentially lead to higher Standard Metabolic Rates (SMRs) and poorer Apparent Digestive Efficiencies (ADEs). One task I wish to accomplish in the following years is to parameterize a general mechanistic model with the aim of modelling the fundamental niche of two Podarcis species (*Podarcis bocagei and Podarcis erhardii*) included in my project.
So far, I have collected data on Body condition, SMR and ADE from male *Podarcis bocagei* individuals. However, during the DEB school I will mostly focus on the SMR data collected at three different temperatures (18, 24, 29 °C). Glyphosate exposed animals experienced higher SMRs at all tested temperature with bigger animals being affected the most.

As modelling framework, I wish to use the NicheMapR Rpackage, which includes biophysical (microclimate and animal models) and metabolic (Dynamic Energy Budget, DEB') models.
Moreover, I wish to use the data I collected to predict the effects of glyphosate on my lizards. To do so I aim to parameterize a module of the standard DEB model (stdDEB-TKTD) which accommodates the effects of toxicants on energetics.
The "bigger picture" of my project is to use those refined models as a tool for projecting the laboratory toxicity tests to the landscape and estimate glyphosate impacts on individuals under field conditions. So, the main question is: How does lizard SMR changes in glyphosate treated agricultural fields under different climatic scenarios and what are the costs of this elevated metabolic state?
The person that introduced me to the fascinating world of DEB models is my supervisor Dr. Urtzi Enriquez-Urzelai who has been working on DEB models for several years. I also had the privilege to collaborate with Prof. Sandrine Charles from the Claude Bernard University of Lyon 1, an expert in the field of ecotoxicological modelling, who hosted me at her lab during a one-month mobility scholarship.
Attending DEB School 2025 is highly relevant to my PhD research and professional development. Although I am still learning the methodologies, I am eager to absorb as much as possible and to apply this knowledge to improve both the analysis of my current data and the design of future experiments. I am confident that this training will allow me to better exploit the full potential of DEB models in my research.
I am very excited to take part in this event and to learn from leading experts in the field. Thank you for the opportunity.

Taylor Linsay

We are using the temperate, facultatively symbiotic coral *Astrangia poculata* to investigate energetics in Scleractinians because of its unique energy dynamics. In the past, I have used compound specific stable isotope analysis to quantify heterotrophic vs. autotrophic inputs to this species. We found that in both symbiotic and aposymbiotic ecotypes of Astrangia, heterotrophy was the dominant source of energetic input. The symbionts acquired a large portion of their energy from the coral host – which is the reverse of what we expect in tropical corals. However, we did see signatures of photosynthesis and nutrient recycling by the symbionts. DEB modeling will be an excellent steppingstone to identify flows of energy and mass within this system. A detailed model will allow us to target specific questions about this system and other Scleractinians in the future.

The main challenge I foresee will be building a DEB model for a symbiotic system. To my knowledge, past attempts at DEB models in corals have treated symbionts and hosts as separate entities. The more we learn about cnidarian biology, the more we discover how intrinsically linked these organisms are. Without a proper way to model symbiosis in this system, I fear we may be missing critical components of the host-symbiont relationship. Especially in a facultatively symbiotic coral, symbionts may contribute to the system in a variety of ways beyond energy acquisition. Past work has shown that symbiotic corals exhibit improved growth, immunity and wound healing, as well as differences in their nutrient cycling, metabolomics and gene expression compared to their aposymbiotic counterparts.

Once we have the model, we are interested in asking questions about how environmental change (specifically light availability and water temperature) affect energy acquisition and flow. We are also interested in maternal provisioning and larval development. For the purposes of the DEB conference we will use existing data to compare effects of ecotype, light availability, and food availability within this system.

Tim van den Bosch

My aim is to use DEB in my PhD research. The focus of my PhD research is on the potential water quality impacts of floating structures (e.g. floating solar) in Dutch waters. For the eventual implementation of these structures, we want to know whether the expected impacts of these structures change depending on its size and its environment and whether they can have a positive impact on the environment. For this last part we want to look at how these structures influence expected attached biofouling such as the blue mussel. To model the growth of mussel populations we aim to use DEB. More precisely, we use the DEB-module within Delft3D. Delft3D allows us to set up a hydrodynamic and water quality model with specific parameters representing specific Dutch waters. The DEB-module uses the required (a)biotic outputs of these models as inputs for its own calculations. While functional there are still a few issues we hope to resolve through this DEB school. Currently multiple parameter sets for blue mussels are being used both with their own issues. We hope to get a better insight into the parameters and hopefully merge these parameter sets into one. Some mechanisms within the DEB module are different (or missing) from standard or other mussel DEB models. Hopefully through this school we get an idea how integral these are. Due to how novel this research topic is, quite a limited amount of research has been performed on this topic. A dataset to validate our results is currently unavailable to us. The datasets from which the DEB parameters were extracted are also quite limited. The extend to which we can expand the DEB module is also dependent on factors such as time and resources.

Tristan Halna du Fretay

My PhD study the impact of climate change on the nursery function of estuaries and especially in the Gironde estuary in the southwest of France. I study the relative impacts of various stress associated to climate change: temperature, food limitation, hypoxia, acidification, contamination and increase salinity. I want to qualify and quantify the impact of those stress on juvenile fish growing in the nursery, first individually, and then determine potential synergistic or antagonist effects between the stress. I mainly study the Common sole (*Solea solea*) as it has a representative life cycle for nursery dependant species. I use DEB modelling to simulate the growth of juvenile soles inside the estuary under various conditions. Then I want to integrate the individual DEB model to a larger population dynamic model. The goal is to study how the effect at an individual level will have repercussions on the population, and compare it to fisheries stock predictions. Lastly, I want to integrate the individual DEB model to a trophic model of the Gironde estuary, in order to study how the trophic network might be impacted. Coming into this course, I mainly want to deepen my understanding of DEB theory, to learn how to set up parameters for a model, and discuss how I could integrate my DEB model at higher levels of organisation.

Urban Dajčman

I am currently finalizing my PhD at the Slovene National institute of biology. My work focuses on understanding species interactions in a changing environment. For this end I am utilizing the DEB framework to study a pair of lacertid lizard species *Podarcis muralis and Iberolacerta horvathi*. My aim is to use DEB models coupled with byophisical models to study the way these species interact along altitudinal gradients throughout their ranges. My main aim in the course is to revise the current entries for both species in the AmP database and use them in my further work. Additionally, I would like to prepare a fresh entry for the Ural owl (*Strix uralensis*) which is a focus of a side project I'm working on looking at how the Bergmann's rule applies to this owl species throughout its range again giving note that it sometimes coexists with owl conspecifics such as *Strix aluco*. During the estimation process I have often observed that for many species we can only really rely on field observed data which is not measured in standard conditions and in widely different environments. As part of the course I would like to discuss how these types of data are best used in the estimation procedures of DEB and what we can do to ensure that the data used is sound and appropriate for the estimation procedure and how/if the conditions where the data was obtained influence the parameter estimation process.

Yiannis Hatzonikolakis

DEB Applications for Tropical Species with Focus on Coral-Zooxanthellae Symbiosis

I am broadly interested in applying Dynamic Energy Budget (DEB) theory to tropical marine species of the Red Sea, including fish, bivalves, and corals. My current research focuses on the symbiotic relationship between reef-building corals and their endosymbiotic algae (zooxanthellae), a partnership critical to coral health and reef productivity. Specifically, I apply DEB theory to simulate and predict coral bleaching; a climate change-induced stress response that disrupts the coral-zooxanthellae symbiosis.

Building on prior work (Cunning *et al.*, 2017; Detmer *et al.*, 2022; Pfab *et al.*, 2022), we implemented a DEB-based symbiosis model to simulate coral bleaching events in the Red Sea. The model was driven by both modelled and satellite-derived environmental forcing data, including temperature, light, nutrients, and zooplankton. Using parameter values (except for one calibrated parameter) from the aforementioned studies we successfully reproduced most of the historical bleaching observations in the region.

While this implementation has proven useful, it is constrained by its generic character. The parameterization is based on physiological traits from various coral species and was not derived using a standardized parametrization methodology. As such, it represents a "generic coral" rather than species-specific dynamics. When attempting to estimate parameters for specific species based on physiological datasets, we encountered challenges, although the model did successfully capture *in situ* seasonal fluctuations in symbiont density within host tissues.

The primary limitations emerged when parametrizing physiological processes such as photosynthesis. Model peculiarities with initialization, described in Pfab *et al.* (2022), complicate the calibration against physiological data like for instance, light–intensity (L–I) response curves.

Zihan Zhou

In my research, I aim to apply Dynamic Energy Budget (DEB) theory to investigate the physiological vulnerability of desert lizards to climate change. The focal species I selected for this course is *Moloch horridus*, a highly specialized desert lizard native to Australia. My broader study includes 233 desert lizard species worldwide, and I plan to construct a DEB model for each one. This will allow me to simulate how individuals allocate energy to maintenance, growth, development, and reproduction under both current and projected microclimatic conditions.

To accomplish this, I am collecting species-specific trait data from the Add-my-Pet (AmP) database, published literature, and field observations. One major challenge is that many species lack comprehensive physiological or life-history data. By integrating DEB models with high-resolution microclimate simulations using *NicheMapR*, I aim to evaluate how different climate scenarios may impact key life-history traits. Specifically, I will assess whether growth rates decline, maturation is delayed, reproductive periods are shortened or lost, and whether there are increasing numbers of days when energy intake falls below the level needed for basic maintenance. These outputs will serve as physiological indicators of climate vulnerability and will enable me to quantify and compare species' exposure across different desert regions.

Participant List

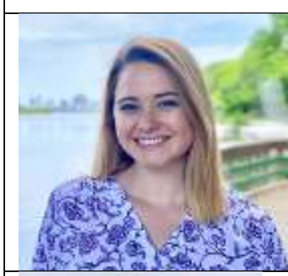
Alphabetically by last name

	Albert, Lauren laalber@iu.edu Indiana University USA School & Symposium	I am a fourth year PhD Candidate in a community-ecology of disease research group. My research is focused on the energetics of disease epidemics at the individual to the population level. Energetic stress from the environment combines with parasite-driven, internal starvation to virulently depress host life history traits while simultaneously constraining within-host parasite production. This hypothesis starts with links between availability of environmental resources to allocation of internal energy within hosts to growth and reproduction. Low resource supply causes energetic stress ('external starvation') that depresses life history

		traits of hosts. These life history traits additionally respond to infection. Parasites that rely on hosts for resources can directly steal or manipulate the host energy toward growth and reproduction. I hypothesize that through this theft, 'internal starvation' inflicts virulence that exacerbates effects of external starvation. Therefore, the external supply of resources plus internal starvation can modify the suite of interconnected life history traits of a host. I study this phenomenon in a planktonic host-parasite system. The host (Daphnia dentifera) becomes infected by consuming spores of a virulent fungus (Metschnikowia bicuspidata) while foraging on phytoplankton. I conducted assays rearing hosts along a resource supply gradient to measure effects of external resource and spore density on life history traits. I measured host age and size at maturation, number and size of offspring, and time of death. To synthesize these results mechanistically, I aim to construct a dynamic energy budget model that explicitly tracks within-host energy depletion by parasites. The energetic framework will connect how both external and internal starvation explain why infection virulently depresses traits of hosts while subsequently imposing limits on parasite production. Host-parasite systems have rarely been explored using DEB modeling approaches. Hence, my participation in the workshop will not only support my individual research but contribute novel applications to DEB theory. Additionally, I aim to share the skills gained during the workshop with others at my institution seeking more fine-scale metabolic understanding. I expect my modeling skills to grow during the workshop, as I engage with more detailed parameterization with my data. I am very excited by the opportunity to infuse my research with a more

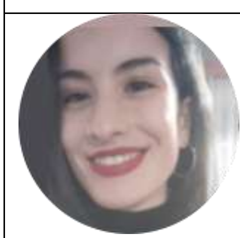
		complete approach to energetics in host-parasite systems.
	Bashkir, Dana dana.bashkir@wur.nl Wageningen University & Research The Netherlands School & Symposium	I am a PhD student working on the use of ecological models in environmental risk assessment of chemicals. I am currently working on a population model of Orius laevigatus that would potentially include a DEB component (there is already an AmP entry). Thus, I want to understand the DEB model properly and figure out how to use it in my research.
	Britnell, Jake Jake.britnell@protonmail.com Nelson Mandela University School & Symposium	
	Ceballos Ramirez, Angel adcr501@york.ac.uk University of York UK School & Symposium	I am a PhD student working with DEB modelling and standardized ecotox tests
	Chary, Killian killian.chary@gmail.com Cirad France School	Dear School organiser, I'm a researcher in aquaculture modeling at CIRAD, located in Montpellier, France. I'm already using DEB models to simulate the metabolism of aquatic species in the context of aquaculture systems. I'm using the DEB as individual growth model for integration into wider farm-scale models that simulate aquaculture operations (feed distribution and use, harvests, waste production, etc.) in dynamic environments. I'm applying to enroll in the DEB2025 school because I'm interested in deepening my knowledge in DEB theory, getting familiar with tools that can be used for DEB simulations, and discovering novel applications related to the method. Furthermore, I would be happy to connect with the network of researchers and students developping the method. Best, Killian

	Coverley, Alex coverley@zoology.ubc.ca University of British Columbia Canada School & Symposium	I'm a PhD student. I work on the energetic trade-offs of acclimation to thermal variability in insects. I am currently making a DEB model of the dung beetle Onthophagus taurus that incorporates my experimental data (metabolic and behavioural). I've seen differences in locomotive preferences between acclimation treatments and across temperature. I am also intending to make a DEB model for the overwintering energetics of the eastern spruce budworm that focuses on the relationship between thermal variability and energetic drain, again using collected experimental data.
	Dajčman, Urban urban.dajcman@nib.si National Institute of Biology Slovenia School	My work is mainly focused on understanding how biotic interactions shape the life hisotries of european lizard species. During my PhD I have encountered DEB theory as a unique tool to answers some of my research questions working on the ecophysiology of lizards, their interspecific interations and as it relates to ecological modelling. Participating in the school while also assisting as a TA will greatly increase my knowledge on the topics and enable me to apply them to my further research.
	Deslauriers, David david_deslauriers@uqar.ca Université du Québec à Rimouski Canada School & Symposium	
	Diele-Viegas, Luisa Maria luisa.mviegas@gmail.com University of Mississippi USA School & Symposium	Learn more about the DEB model to apply to my research and share with my students

	Donati, Elisa Edonati@ogs.it National Institute of Oceanography and Applied Geophysics Italy School & Symposium	I am a PhD student in marine ecology at the National Institute of Oceanography and Applied Geophysics in Trieste, Italy. I am using DEB Theory to develop an agent-based model, written in Julia Language, for sardines and anchovies populations in the Adriatic Sea. The aim is to produce a friendly tool to track past and future population biomass trends but also test how life-history traits of both species are changing and will change due to climate change and anthropogenic stressors. I would like to explore how adaptation and evolution can be integrated in my model to test whether different forcings shift in the distribution of DEB parameters in a population. The school will be useful to improve my knowledge on how to apply DEB theory to answer evolutionary questions, what is possible to test, and what is not in coherence with the theory assumptions. Ultimately, it would be a great opportunity to connect with DEB community. Thank you for considering my application, Elisa Donati
	Fleming Ianniello, Caroline cgflem@bu.edu Boston University USA School & Symposium	
	Geček, Sunčana suncana.gecek@gmail.com Ruđer Bošković Institute Croatia School & Symposium	I am a researcher with basic DEB modeling experience and aim to broaden my expertise. I intend to supplement the existing DEB model for the mussel Perna canaliculus with a plastic ingestion module and learn how to evaluate the impact of ecotoxicants using DEB theory. I also plan to advance a model for the sea urchin Paracentrotus lividus by incorporating an additional set of measured data, including thermal response data. This model is important not only for conservation—helping us predict how the organism might respond to climate change worldwide—but also for

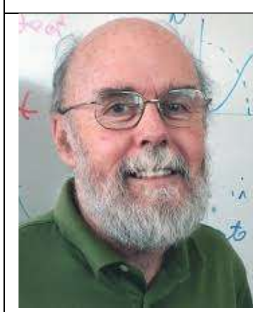
		parameter estimation that supports sea urchin aquaculture management. The DEB School appeals to me because, in addition to reinforcing theoretical foundations, it offers hands-on training in parameter estimation (AmP procedures), which is crucial for accurate ecophysiological modeling. I believe that collaborating with experienced DEB scientists at the School will enable me to apply this theory more effectively in my research.
	Gergs, Andre andre.gergs@bayer.com Bayer AG Germany School & Symposium	Course instructor
	Gollot, Lisa lisa.gollot@agroparistech.fr INRAE France School & Symposium	Currently doing a PhD on "Modeling of eco-evolutionary dynamics of earthworms exposed to a pesticide mixture", I have a an experimentation part to obtain data on the life-history traits of the earthworm Aporrectodea caliginosa exposed to a binary mixture of an insecticide and a fungicide but I am also working on a DEB-TKTD model that would take into account the data that I obtained on the mixture. To whom it may concern, I am a PhD student working on "Modeling of eco-evolutionary dynamics of earthworms exposed to a pesticide mixture." My research combines both an experimental and a modeling approach. I am conducting an experiment to obtain data on the life-history traits of the earthworm _Aporrectodea caliginosa_ exposed to a binary mixture of an insecticide and a fungicide. In parallel, I am developing a DEB-TKTD model to integrate these experimental data and better understand the effects of pesticide mixtures on earthworm physiology and population dynamics. Attending this school would be a great opportunity to strengthen my

		understanding of DEB models, refine my approach, and exchange ideas with researchers in the field. I would love to take part and learn from this experience. Best regards, Lisa GOLLOT PhD Student in ecotoxicology modeling Université Paris-Saclay, INRAE, AgroParisTech, UMR EcoSys, 91120 Palaiseau, France Experimental Toxicology and Modeling Unit, INERIS, 65550 Verneuil en Halatte, France
	Grieco, Gaia g.grieco@ecos.au.dk Aarhus University - ECOSCIENCE Deparment Denmark School & Symposium	
	Hackenberger, Domagoj domagojhack@gmail.com Department of Biology, Josip Juraj Strossmayer University in Osijek Croatia School & Symposium	
	Hale, Jason jason.adams.hale@upc.edu Universitat Politecnica de Catalunya (Spain) School & Symposium	I am a PhD student, my thesis title is ¨Modelling Microbial Activity To Improve Sustainability Of Sub-Surface Flow Treatment Wetlands¨. I am developing a DEB model including 3 taxa of bacteria in wastewater treatment wetlands. the model will also include nitrogen cycle and production of EPS, which is a key component of clogging, and so a challenge in treatment wetland operation and service life.
	Halna du Fretay, Tristan tristan.halna-du-fretay@inrae.fr INRAE School & Symposium	I am a PhD student in its first year in the National Research Institute for Agriculture Food and Environment (INRAE) based in Gazinet-Cestas. My work focuses on the impact of climate change, and the different associated stresses (hypoxia, temperature, contamination...) on juvenile fish found on nursery grounds. The goal is to study the individual and potentially synergistic effect of those stresses at

		various level (individual, populational and ecosystemic). I use DEB modeling to simulate the individuals under those various conditions. I want to participate in the DEB summer school in order to deepen my knowledge and understanding of the DEB theory, as well as being able to exchange with other researchers using DEB models.
	Hatzonikolakis, Yannis ioannis.chatzonikolakis@kaust.edu.sa King Abdulah University of Science and Technology (KAUST) Saudi Arabia School & Symposium	I am a post doc working on coral bleaching predictions based on DEB theory
	Kearney, Michael R. (Mike) m.kearney@unimelb.edu.au University of Melbourne Australia Course & Symposium	course instructor
	Klagkou, Evridiki evridiki13@hotmail.gr University of Crete, Greece Course & Symposium	Course teaching assistant
	Kooijman, Bas salm.kooijman@gmail.com A-Life, VU, The Netherlands Course & Symposium	Course instructor
	Lagunes, Maria José mj.laguneslopez@gmail.com IRD -INSTITUT DE RECHERCHE POUR LE DEVELOPPEMENT School & Symposium	I am a PhD student working with multi reserves DEB model. The participation in this school will allow to me to learn more about the DEB model and exchange with other researcher about the question we can answer with DEB model theory.

	Le Moan, Eline eline.lemoan@univ-brest.fr Université de Bretagne Occidentale School & Symposium	I am a PhD student in marine biology, in Brest, France. My project aims on developing a model to study the contamination and decontamination dynamics of pectinids (type of shellfish), by domoic acid, an amnesic shellfish toxin produced by microalgal species. The domoic acid retention varies among species, with slow depurators such as king scallops (Pecten maximus), and fast depurators such as Chilean scallop (Argopecten purpuratus). Because the mechanisms are not known yet, using a comparative approach can help. I have already some experience with DEB theory since I followed the DEB tele-course and participated to the DEB school in 2023 in Baton-Rouge, Louisiana. My participation in the DEB2023 school has encouraged me to develop a new chapter in my PhD, using multi-species DEB parameter estimation to compare the physiology of five pectinid species in order to compare their toxin retention. I am eager to participate in this school to explore novel approaches for using DEB theory into my research project. I am currently working on a DEB model coupled with a domoic acid contamination and decontamination module for both P. maximus and A. purpuratus. The school will be an opportunity to discuss the underlying processes for models with toxin retention. I would also like to discuss the modelling of the toxin assimilation process, and how to improve my model.
	Lavaud, Romain rlavaud@agcenter.lsu.edu LSU AgCenter, USA Course & Symposium	Course instructor

	Lika, Dina lika@uoc.gr University of Crete, Greece Course & Symposium	Course instructor
	Limnios, Anastasios anastasios.limnios@cibio.up.pt CIBIO-BIOPOLIS School	I am Anastasios Limnios, a BIODIV PhD student at the University of Porto. My PhD project is titled "Uncovering the synergistic effects of climate change and pesticides on ectotherms using lizards and mechanistic modelling". During my PhD, I aim to assess the synergistic effects of Glyphosate with increased temperatures and lack of water availability on reptiles. More, precisely on their standard metabolic rate, digestive efficiency, thermoregulation and body condition. One of the main tasks of my PhD is to use the results from the experiments that I am currently conducting to develop DEB models to estimate the potential effects of glyphosate under different climatic conditions in the present but also in the future in agricultural landscapes for two different Podarcis species. Thus, I strongly believe that DEB school is of paramount importance for the development of my PhD.
	Lindsay, Taylor tayrlindsay@gmail.com Tufts University School & Symposium	
	Marek Ortiz, Clarisa clarisa.marek@unc.edu.ar Instituto de Diversidad y Ecología Animal (CONICET - Universidad Nacional de Córdoba), Argentina School	I am a PhD student in Biological Sciences at the University of Córdoba, Argentina. The objective of my thesis is to evaluate the single and combined effect of fungicides and heat waves on a native Argentinean chironomid (Chironomus xanthus) by performing laboratory bioassays throughout the life cycle and the following generations. I would like to use the experimental results obtained to develop DEB models and simulate other exposure scenarios. I

		have no previous experience in these models, but I started to learn about the subject from the DEB telecourse and literature reading. Now I would like to participate in DEB School to learn how to estimate the parameters of my species of interest in DEB basic model and then move on to DEBtox.
	Marn, Nina nmarn@irb.hr Rudjer Boskovic Institute Croatia Course & Symposium	Course instructor
	Marques, Gonçalo goncalo.marques@tecnico.ulisboa.pt University of Lisbon, Portugal Course & Symposium	Course instructor
	Nisbet, Roger rogernisbet@ucsb.edu University of California, USA Course & Symposium	Course instructor
	Oliveira, Diogo diogo.miguel.oliveira@tecnico.ulisboa.pt Instituto Superior Técnico, Universidade de Lisboa, Portugal School & Symposium	School teaching assistant

	Oluwatosin Adekunle, Familusi familusiadekunle@gmail.com School & Symposium	
	Ortiz Duran, Elizabeth Alejandra aleordu@hotmail.com Wageningen University and Research The Netherlands School & Symposium	I'm a PhD student at Wageningen University and Research in the Aquaculture and Fisheries group, working under the supervision of Jaap van de Meer and Karen van de Wolfshaar. I have a background in mathematics, and my research focuses on the individual and population level consequences of large scale sand extraction and climate change for European plaice and brown shrimp. To explore these impacts, we apply the Dynamic Energy Budget (DEB) model to simulate how climate and environmental changes affect the growth, maturation, reproduction, and mortality of these species. Our ultimate goal is to gain insights into how plaice populations may be dealing and adapting to these changes and what the future might hold for this species. I'm currently starting the second year of my PhD, and participating in the DEB2025 School would be incredibly valuable. It would help me deepen my understanding of DEB theory and expand my knowledge and practical skills in applying the model. It would also be an excellent opportunity to connect with people from diverse backgrounds who share an interest in DEB, creating new opportunities for collaboration.
	Pitsika, Katerina katepitsika@gmail.com Hellenic Centre for Marine Research, Greece School & Symposium	I am a marine biologist currently engaged in research focused on the physiology and ecology of zooplankton, with particular emphasis on copepods. My recent work involves compiling and analyzing experimental data on Acartia spp and Oncaea spp, including respiration, ingestion and egg production, in order to parameterize a Dynamic Energy Budget (DEB) model for these ecologically and commercially important species. This effort aims to provide a comprehensive understanding of the species' bioenergetics and their

		role in marine food webs. I am highly motivated to participate in the DEB2025 School to deepen my understanding of DEB theory and its practical implementation. I am particularly interested in learning practices for linking experimental data with DEB parameters. This training will directly support my ongoing work and help refine the model I am developing for A. tonsa. I believe that gaining a solid foundation in DEB theory through this course will not only enhance the scientific quality of my current research but also expand my future research capabilities in marine ecological modeling. I look forward to engaging with the DEB community.
	Rakka, Maria mrakka@dal.ca Dalhousie University School	I am a postdoctoral researcher at Dalhousie University in Canada. My research focuses on deep-sea ecology, and especially on the impacts of climate change on deep-sea coral habitats and communities. I have a background on physiology, as well as on statistical ecological modelling. In my current project, I would like to expand my interests, and use mechanistic models to better understand potential impacts of climate change on the physiology of deep-sea corals. More specifically, I would like to use DEB models to better understand how warming may affect the metabolism and growth of selected deep-sea coral species. I first heard of the DEB theory during my PhD, and found it extremely interesting and useful for my research. I have completed the DEB tele-course in the past, but I would like to follow the whole course to gain further insights to the theory, and get hands-on experience with the process of building the models. This course will be an excellent opportunity to learn more about mechanistic models and get practical experience with their use.

	Rastello, Kévan krastello@uvic.ca Univeristy of Victoria School & Symposium	I am a PhD Student at the University of Victoria, Canada. My PhD is focusing on modelling the dynamics of mountain pine beetles (MPB) in complex forest ecosystems under climate change. I aim to develop an hex Dynamic Energy Budget (DEB) model to understand how individual beetle allocate energy to essential function such as maintenance and growth under different temperature regimes. Building on this model, my goal is to formulate a cryoprotection extension to this DEB model to track energy allocation to cryoprotection during the larval stage. I will use experimental data on energy expenditure for cryoprotection across different temperatures to inform the cryoprotection extension. This DEB model will then be used to quantify how much energy overwintering MPB larvae spend on cryoprotection relative to other energetic costs like maintenance, growth, and reproduction. Ultimately, the goal of the DEB is to quantify how the effect of increased average temperature and temperature variability impact MPB energetics and fecundity at the individual and population level. During this training, I would like to learn how to incorporate external data information to the original formulation of the DEB. Additionally, I would like to learn how to simulate the DEB model at the population level based on individual-level dynamics, while incorporating variability in population traits.
	Récapet Charlotte charlotte.recapet@normalesup.org Université de Pau et des pays de l'Adour France Course & Symposium	Course instructor

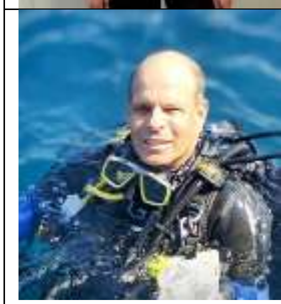
	Robinson, Alexander alerob@ceh.ac.uk UK Centre Ecology & Hydrology School & Symposium	
	Schepers, Hans hans.schepers@gmail.com School & Symposium	
	Schneider, David david.schneider1@bayer.com Bayer AG School	I am a scientist (chemist/biophysicist by training) at Bayer CropScience, and I have only recently transitioned into the areas of ecotoxicology and modeling. Attending the DEB 2025 event presents an excellent opportunity for me to get a better understanding about the basic concepts and to deepen my knowledge and skills. I am eager to understand the latest developments in DEB modeling and explore their application to ecological risk assessments, which are crucial for ensuring the safety and sustainability of our products. As someone who is new to ecotoxicology and modeling, I believe this event will provide a valuable platform to learn from leading experts and exchange experiences with other professionals facing similar challenges. By participating, I hope to gain insights that I can directly integrate into my work to enhance ecotoxicological evaluations at Bayer, ultimately contributing to more informed regulatory decisions. I am convinced that the concepts and techniques learned will strengthen my ability to develop more precise and robust models that are significant for our projects in regulatory risk assessment. Networking with other participants will help me gain new perspectives and develop innovative approaches. I look forward to the opportunity to participate in this important event and actively contribute

		to the discussion and knowledge exchange.
	Schouten, Rafael rafaelschouten@gmail.com University of Melbourne, Australia School & Symposium	I am about to start a postdoc working on DEB models of plants and animals in Australia. I have previously published papers on DEB plant modelling but would like to broaden my knowledge to animal models and multi-organism models.
	Senzano, Luis Miguel lm.senzano@gmail.com Sâo Paulo State University, Brazil School & Symposium	Participating in the full DEB2025 event is essential for my post-doctoral research, as it directly aligns with my goal of incorporating a quantitative framework to understand temperature, water, and (possibly) energy balance in amphibians. The DEB theory provides a powerful mathematical approach to model how organisms allocate energy for growth, maintenance, and/or reproduction under varying environmental conditions—key aspects for assessing the physiological constraints amphibians face in seasonal Neotropical habitats. Although I am currently working on mechanistic modeling, I have had limited formal opportunities (such as courses) to learn and apply advanced mechanistic tools for modeling. To be honest, most of my analytical skills in mechanistic modeling have been acquired through books and published papers. This event represents an excellent opportunity to expand my knowledge in this area, allowing me to strengthen my theoretical and practical skills in dynamic modeling approaches. By participating in the DEB2025 thematic school and symposium, I expect to refine my modeling approaches and, if possible, integrate DEB principles into my work while engaging with experts applying these frameworks across diverse ectothermic systems. Furthermore, this experience will enable me to bring the knowledge gained back to my lab in Brazil, fostering advancements in mechanistic modeling within my research group.

	Sousa Tânia taniasousa@tecnico.ulisboa.pt University of Lisbon Portugal School & Symposium	Course instructor
	Sulc, Anna sulca@uw.edu University of Washington, USA School & Symposium	PhD student. Monitor data in stock assessments in data-limited situations. Develop rebuilding plans for overfished stocks.
	Tjui Yeuw, Tan tan.tjuiyeuw@wur.nl Wageningen University and Research The Netherlands School & Symposium	School teaching assistant
	van den Bosch, Tim t.vandenbosch@uu.nl Utrecht University The Netherlands School & Symposium	I am a PhD student at Utrecht University and Deltares. For my project I aim to research how floating structures (e.g. floating solar panels) impact the water quality and local mussel populations attached to it. For this we want to use DEB to model these mussel populations in the North Sea. We hope to gain a deeper understanding of DEB, clarify the parameters sets we have available and implement it into the currently available water quality models at Deltares.
	Van der Meer, Jaap jaap.vandermeer@wur.nl Wageningen University and Research The Netherlands School & Symposium	Course instructor

DEB 2025
9th International Symposium and Thematic School on DEB theory for metabolic organization
May 2025, Heraklion (Greece)

	Vannucchi, Fabio fs.vannucchi@unesp.br São Paulo State University (UNESP), Institute of Biosciences, São Vicente, Brazil School & Symposium	I am a university assistant professor in the Department of Biology and Environmental Sciences, and I have a background in statistical physics. My current research focuses on mathematical modeling of biological processes, particularly in the context of ecophysiology and conservation. I am particularly interested in applying theoretical frameworks to support population viability assessments and management strategies for threatened species. Attending this School and Symposium represents a unique opportunity to deepen my understanding of DEB theory and expand my research network. I aim to integrate DEB models into my ongoing work, enhancing our ability to predict and analyze species responses to environmental changes. I look forward to engaging with experts in the field and exploring potential collaborations to advance the application of DEB theory in conservation science.
	Verhille, christine christine.verhille@montana.edu Montana State University, USA School & Symposium	I am an associate professor. I have a PhD student using DEB modelling. I am interested in parameterizing DEB model for a stonefly and eventually using multi-teir parameterization to incorproate inter-individual variation.
	Veron, Matthieu mateohveron.fish@gmail.com Institut Agro Rennes-Angers France School & Symposium	

	Veseli, Marina marina.veseli@irb.hr Ruđer Bošković Institute Croatia School & Symposium	
	Yahel, Gitai Yahel@Ruppin.ac.il Faculty of Marine Science, Ruppin Academic center Israel School & Symposium	I am a coastal oceanographer and marine biologist. For the past 30 years, I have focused on various aspects of biological filtration, primarily at the smaller end of the particle size spectrum (micrometer and submicrometre scale particles and dissolved organic matter). Recently, my lab has shifted to studying different facets of suspension feeders' metabolism. Consequently, I am eager to learn the fundamentals of DEB Theory and its potential applications in my area of expertise. I am a complete novice in this field and have no prior experience in modeling, so I need to learn this topic from the ground up. Naturally, I am also very busy with teaching and other academic responsibilities, and I genuinely hope to complete the online course before the meeting.
	Zagar, Anamarija anamarija.zagar@nib.si National Institute of Biology Slovenia School	I am a researcher, studying species interactions and ecophysiology in lizards and other ectotherm organisms, focusing also to climate change research. I've started using DEB theory together with my PhD student Urban Dajcman and in collaboration with researcher Urtzi Urtzelai, who is already experienced with DEBs. I would like to better understand the theory and its application in ecological studies and predictive power of mechanistic modelling using DEB theory to forecast responses of ectotherms physiology to climate change.

	Zhou, Zihan zhouzh223@mail2.sysu.edu.cn Sun Yat-sen University China School & Symposium	I am an incoming PhD student studying the impacts of climate change on desert lizard communities. Through this training, I hope to deepen my understanding of energy and mass balance and explore the application of DEB theory in my research. Specifically, I aim to incorporate the DEB model to estimate water demand by considering lizards' water intake and production. This knowledge will enhance my ability to assess how desert lizards respond to changing environmental conditions and improve my mechanistic modelling approaches.