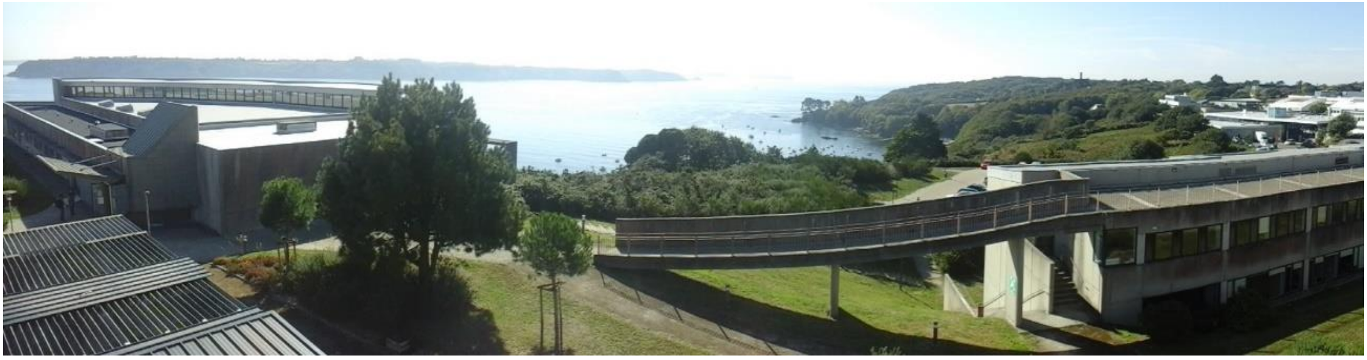
DEB school & workshop

1 – 6 April (School) & 8-9 (workshop) 2019 Brest, France



The DEB school is an advanced training course on Dynamic Energy Budget (DEB) theory. The objective is (i) to learn fundamental DEB theory concepts, (ii) to train participants to apply DEB modelling to support their research and (iii) formulate their research questions. All applications of models come with the need to know parameter values so the course places due emphasis on extracting parameter values from real data.

The course comprises a balance of theory (lectures), exercises, scientific discussions and working on an own "Pet project". The individual "Pet projects" are dedicated to estimating DEB parameters for an animal[1] from data using the AmP procedure[2]. DEB theory and associated parameter estimation methods can later be applied to the more complex cases once the student masters the basics.

The course takes place in Brest (European Institute of Research on the Sea IUEM) and marks four decades of research, development and application of DEB theory. This consistent 40-year DEB program results in DEB theory being the best tested quantitative theory on metabolic organisation; as such it has strong potential to support designing, carrying out and interpreting ecological/biological investigations. During the entire course, participants will interact with skilled scientists actively involved in applying DEB to their own research. Biodiversity slide shows and discussion will take place in the evenings is a cosy atmosphere. This is the 6th edition of the DEB school: it builds upon our previous experience and is designed to foster networking and strengthening international cooperation. It further builds upon the last edition and includes new material and insights stemming from the latest phase in the DEB research program.[3]

The course will be followed by a 2-day workshop and 3-day symposium. The series of 4 workshops where tools and know how on how DEB is being applied in four major fields are shared: reconstruction problems, ecotoxicology, biophysical ecology and population/ecosystem biology. The workshops integrate theory and practice and are concluded by a moderated plenary discussion among attendees. The objective is to gather scientists and students from various fields and to stimulate discussions. This will be the opportunity to mix people having followed the school with the ones coming for the symposium.

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[1] If the participant is not working with animals, they perform the exercise on an animal in order to learn, because estimating parameters from animal data is simple with respect to that of e.g. bacteria, algae or plants.

[2] Marques et al., "The AmP Project: Comparing Species on the Basis of Dynamic Energy Budget Parameters."(2018) PLOS Computational Biology.

[3] Augustine and Kooijman, "A New Phase in DEB Research."(2018) Journal of Sea Research.

1 Course schedule

	School								Workshop	
	Sun 31 March	Mon 1 April	Tues 2 April	Wed 3 April	Thurs 4 April	Fri 5 April	Sat 6 April	Sun 7 April	Mon 08 April	Tues 09 April
9:00-09:30		"Summary tele-course" (S. A.)	"DEB applications in ecology" (Y. T.)	"Running the DEB model" (L.P.)	"Accelerations and evolution of acceleration" (S. K.)	"Multivariate DEB models" (G. M.)	DEB ecology (J.F-S.M.)		"DEB in ecotoxicology"	"Biophysical Ecology" (M. K.)
09:30 - 10:00									"Lessons frm NIMBioS W.G." R.N.	
10:00 - 10:30		Break	Break	Break	Break	Break	Break			Break
10:30-11:00		AmP: guided example (K. L.)	DEB in practice	AmPecology/ Estimation in context/ AmP tool (SA)	"Ecotox and Ecosystems" (R. N.)	AmP	AmP		"Case study" A. H.	DEB in practice biophysical ecology (M. K.)
11:00-11:30									wrapping up/ MODERATED DISCUSSION	
11:30-12:00					AmP					
12:00-12:30		Lunch							Lunch	
12:30 - 13:00										
13:00-13:30		"Overview of the AmP procedure" (G. M.)	DEB in practice	"Sensitivity Analysis" (K. L.)	AmP	"The metabolic theories of ecology" (M.K.)	Plenary discussion (R. N.)		"Trajectory recontruction" (L.P.)	DEB in practice biophysical ecology (M. K.)
13:30-14:00	Arrivals and settling in								DEB in practice reconstruction	
14:00 - 14h30		"Alternative Approaches" (S.K.)		AmP		Group discussion	AmP presentations	Day off		"Individuals to populations to community" B. K.
14:30-15:00			Group discussion							
15:00-15:30		Break			Break	Break	Break		Break	Break
15:30-16:00		"Covariation of parameter values" (K. L.)	Break	Break	Group discussion	LECTURE	AmP presentations		DEB in practice reconstruction	DEB in practice individuals to populations to community (B. K.)
16:00-16:30			AmP	"Ecotox & Ecosystem Dynamics" (R. N.)						
16:30-17:00		AmP			Confidence intervals	AmP	Break		Break	Break
17:00-17:30				Group discussion			AmP presentations		AmP applications in ecotox, population biology, biophysical ecology	DEB in practice individuals to populations to community (B. K.)
17:30-18:00										
18:00-18:30		Personal time	Personal time	Personal time	Personal time	Personal time	Personal time		Personal time	Personal time
18:30- 19:00										
19:00-20:30	Welcome and Dinner	Dinner	Dinner	Dinner	Dinner	Dinner	Dinner			
20:30 - 21h30		Group discussion	Biodiversity slide show (S. K.)	Plenary discussion (R. N.)		Group discussions	Biodiversity Slide Show (S. K.)			

2 Learning objectives

- Formulate a research question
- Know core DEB concepts and associated alternative concepts
- Able to estimate DEB parameters from real-world data
- Discuss biological realism of DEB parameters
- Apply DEB parameter estimation to support your own research
- Capacity to apply DEB to address contemporary problems in conservation, environmental impacts and resource management

3 Contents of the 57.5 Practical course

3.1 6-day school (1-6 April)

Active learning via practical exercises	7.5 h
Theory (lectures)	14h
Research question formulation (group discussions)	6h
Debate (plenary discussions)	2h
Individual "Pet projects" working time	12h
Presenting results of individual projects	3h
Total:	53h

3.2 2-day workshop (8-9 April)

Theory (lectures)	4h
Practical exercises	7h
Discussion/debate	2h

4 Items to bring to Brest

You can read online about travel info.
Please bring with you:

- Walking shoes
- Laptop with matlab 2006 or higher
- Recent version of DEBtool and AmPtool
- A well prepared mydata file for your pet
- List of participants (we skip introductions):

If you don't have a Matlab license, there are two viable options:

- Download the free 30-day trial version from mathworks.com. Organize it so that these 30 days includes your visit to Brest.
- Buy the Student version of Matlab if you are a student at a university. The student version apparently has all the capabilities of Matlab and is cheap (35 Euro excl. VAT for the basic program).

5 DEB2019 Team

5.1 Leaders discussion groups

Bob Kooi, Gonçalo M. Marques, Laure Pecquerie, Nina Marn

5.2 Assistants exercise groups

Gonçalo Marques; Dina Lika; Laure Pecquerie; Starrlight Augustine; 'Bas' Kooijman; Nina Marn; Yoann Thomas; Jonathan Flye-Sainte Marie

5.3 Lecturers

Michael Kearney (M. K.), Bob Kooi (B. K.) , Sebastiaan 'Bas' A. L. M. Kooijman (S. K.)
Konstadia 'Dina' Lika (K. L.), Gonçalo M. Marques (G. M.), Roger Nisbet (R. N.), Starrlight Augustine (S. A.), Laure Pecquerie (L. P.), Yoann Thomas (Y. T.), Jonathan Flye-Sainte Marie (J. FSM)

5.4 Leaders plenary discussions

Michael Kearney; Roger Nisbet

5.5 Leader Add-my-pet presentations

Laure Pecquerie

5.6 Onsite support crew for Symposium

https://deb2019.sciencesconf.org/resource/page/id/3

6 Individual "Pet projects"

Objective: Parameter estimation on the basis of the submitted mydata- file. Every person will be assisted by the team. In addition to the task and learning objectives outlined below, this time working on the projects 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.

Several participants from DEB2017 used the work performed in their project as a basis for work they subsequently published in the DEB2017 Special issue on DEB theory (e.g. Stubbs et al 2018, Joseph & De Schamphelaere 2018).

6.1 Tasks:

- compose a predict_my_pet file for your pet
- fill out the ecological information of the species using AmP ecology coding system
- estimate parameters values using run_my_pet
- compute over 100 implied properties of your pet
- compare resulting parameters with with those of other animal taxa

6.2 Learning objectives:

- Create user defined predictions for length, weight, reproduction and/or respiration data with the help of the DEBwiki, DEBtool and AmP websites, see Marques et al 2018.
- Know how to use the AmP ecology module
- Control parameter estimation by setting options in run_my_pet and/or setting weight coefficients in mydata_my_pet
- Saving results and choosing starting values for parameter estimation by setting options in run_my_pet
- Computing goodness of fit
- Discussing goodness of fit in (biological) context

6.3 Assessment:

Pet presentation of main findings.

6.4 Pets

First Name	Pet (Latin Name)	Pet (English Name)
Starrlight	*Boreaogadus saida*	polar cod
Nina	*xxx*	xxxxx
…	...	…

The table will be filled out as people choose their pets.

7 Contents of Lectures during the 6-day school (1-6 April)

7.1 Lecture "Summary of the DEB-tele course" (Starrlight Augustine 1 H)

Learning objectives:

- Define strong homeostasis (chemical indexes, chemical potential)
- Define structural homeostasis
- Compare differences in how chemical composition changes with growth rate between (a) an individual over its ontogeny subject to constant food and (b) between two individuals where one is subject to constant high food and the other is subject to constant low (but sufficient) food. Explain the roles of weak and strong homeostasis to capture (a) and (b)
- List the processes of the standard DEB model and write out the macro-chemical reaction equations for each process
- Convert an equation from an energy-length-time framework to a mass-length-time framework.
- Provide at least one reason that it is more complex to perform a mass balance than an energy balance.

7.2 Guided AmP example (Konstadia Lika 2H)

Step by step guided example of estimating parameters for the spurdog *Squalus acanthias*.

7.3 Lecture "Overview of the AmP procedure" (Gonçalo Marques & Laure Pecquerie1 H)

Topics:

- Real world VS fantasy world
- Typified models
- Short history/introduction to AmP
- Purpose of estimation, start from bijection
- Data: zero-variate and uni-variate
- Parameters: core and auxiliary
- Understanding of the several components of the estimation: Nelder-Mead method, filters, pseudodata
- Evaluation of the estimation: assessment criteria MRE & SMSE
- Code architecture

Reading: Lika et al. [1], Lika et al. [2]

7.4 Lecture "Alternative approaches to modelling metabolism" (Sebastiaan Kooijman 1 H)

Metabolism is the set of chemical transformations in living cells to maintain and propagate life. Life originated as prokaryotes, so their metabolism might reveal aspects of metabolic organisation that is at basic to metabolism in general. I briefly discuss a possible evolutionary scenario for the evolution of central metabolism and the metabolic organisation of eukaryotes.

Models for metabolism can generally be classified as the biochemical (bottom-up) approach, where a (small) number of particular chemical compounds are followed, and the pool (top-down) approach, where pools of metabolites are followed, which do not change in composition (strong homeostasis). Both approaches have strengths and weaknesses. Mixtures of both approaches suffer from the problem of the huge range in time and spatial scales even for unicellulars. An intermediate one, however, which deals with the a few interacting biochemical modules might possibly link both approaches and serve as communication channel.

Among the pool models, single pool (called "biomass") models are most frequently used, and especially what became known as production (or scope for growth) models. Losses of acquired resources are first subtracted from inputs and the remaining part is allocated to growth and/or reproduction. This approach will be compared with assimilation models, of which the DEB model is an example. The interpretation of respiration, which is generally seen as a quantification of metabolic rate, and the use of allometric functions will be discussed in the context of all possible internal organisation schemes.

This type of presentation cannot be done without my views on the various alternatives. I don't ask you to agree with my views, but invite you to think about the arguments that will be presented.

Background material: Kearney et al 2010, Kooijman 2010, Kooijman & Hengeveld 2005, Kooijman & Segel 2005 [6], Kooijman & Troost 2007, Lika & Kooijman 2011

7.5 Lecture "Covariation of parameter values" (Konstadia Lika, 1H)

- Scales of life in time & space
- Primary vs compound parameters
- Covariation of parameter values
    - Intensive & extensive parameters
    - Primary and secondary scaling relationships
- Comparisons of intra- and inter-specific scaling relationships
- AmP – patterns in covariation of primary parameters

Primary Reading: chapter 8, Kooijman 2018

Additional Reading: Kooijman et al 2008., Lika et al. 2014

7.6 Lecture "Ecological Applications of DEB Theory" (Yoann Thomas, 1H)

How DEB theory may help in studying the effect of environmental variability on species performances?

- Climate change effect on marine species
- Individual-based species distribution modelling
- Life-cycle and life-history traits

Some of the reading: Pethybridge et al. 2013, Thomas et al. 2018, Filgueira et al. 2016, Thomas & Bacher 2016

7.7 DEB in practice: Estimation in Context (3H)
Leader: Starrlight
Assistants: Gonçalo, Laure, Dina, Bas, Nina

7.7.1 Summary
Deep-sea fishing started without much knowledge of the life-history characteristics of the newly exploited stocks. Is it possible to say something at all about growth and age at maturity without being able to age specimens, know anything about their reproduction or being able to raise them in the laboratory?
We will work with the Greenland shark *(Somniosus microcephalus).*
Results will be discussed in a wider context of eesource management (deep sea fisheries) and with respect to published work by from van der Meer et al 2014 on the Atlantic hagfish.

7.8 Lecture "Running simulations with the DEB model" (Laure Pecquerie, 1 H):
- State variables, parametes of the DEB model
- Simulating growth and reproduction as function of temperature and food
- Reconstruction problems with DEB

7.9 Estimation in context & AmPtool (Starrlight Augustine 1.5 H)
Topics:
- Judging parameter values in biological and evolutionary context
- AmPtool software for analysis of patterns in parameter values
- AmPecology: eco-codes for species, querying species by ecological properties in AmP
- Analysis of DEB parameters in ecological setting

7.10 Lecture "Sensitivity Analysis" (Konstadia Lika 1 H)
Topics:
- Parameter identification
- Confidence intervals
- Sensitivity
- Monte Carlo simulations

7.11 Lecture "Ecosystem Dynamics" (Roger Nisbet 1 H)
Topics:
- Energy flow and material cycling in ecosystems
- Stoichiometry in DEB
- Simplest DEB ecosystem model (canonical community)
- From molecules to ecosystems with DEB

7.12 Lecture "Accelerations and evolution of accelerations"(Sebastiaan Kooijman 1 H)
Application of the standard DEB model to a large number of animal species learned that quite a few species did not fit that model over their full life cycle. Deviations allowed a classification in 5 modes of acceleration, which is defined as a long-term increase in metabolic rate during ontogeny, compared to expectations of the standard DEB model. I first briefly review some properties of the standard DEB model to introduce deviations from it. The 5 modes are an increase in maturation, assimilation, body temperature and changes in diet and morphy-type (temporary V1-morphy, as opposed to continued iso-morphy). I will discuss examples for each of these modes, and discuss ecological and evolutionary contexts where possible.
Background material: Kooijman 2010, Kooijman 2014, Kooijman et al 2011, Lika et al 2014, Mueller et al 2012

7.13 Lecture "Individual-based and structured population models of interacting species" (Roger Nisbet 1 H)
- Concepts for individual-based and structured population models
- Daphnia as model organism
- DEB-IBM – with demonstration
- testing an IBM
- applications to ecotoxicology
- future challenges

Primary Reading: section 9.2. [4]
Additional Reading: Martin et al. 2012, Martin et al. 2013, Martin et al. 2014

7.14 Practical application of interval estimates (Konstadia Like and Starrlight Augustine 1.5 h)

Topics:

- Monte Carlo method for interval estimates
- DEBtool software for the monte carlo method

7.15 Lecture 13 "Multivariate DEB models" (Gonçalo Marques 1H)

- Synthesizing units: complementary compounds DEB2017_Marques_2.pdf
- Multiple reserves: excretion, damming up
- Nutrient limitation
- Multiple structures: static and dynamic
- Plants
- Multiple maturities?

7.16 Lecture "The Metabolic Theories of Ecology" (Michael Kearney, 1 H):

- Role of budgets in ecology: theoretic vs empirical
- Comparison of existing approaches: bryozoans
- Long-term perspective for bio-energetics

7.17 Guest Lecture (1 H)

7.18 Lecture "Ecological applications of DEB theory" (Jonathan Flye Sainte Marie 1 H)

- From in-situ or in-vitro experimental work to modelling
- Case study on the effect of hypoxia on marine species

8 School (1-6 April): Group discussions

6-8 people per group discussion

The chair(wo)man appoints a reporter, who will summarize the discussion during 5 min in the plenary discussions. In each hour, 2 participants have a 10 min presentation on the problem that they submitted in 0.5 A4 at the end of the tele-part, followed by a 10 min discussion per presentation.

The remaining time (some 10 min per hour) we discuss:

- TOPIC 1: Theories vs. models: What is the difference between them and how are they related, particularly in the context of DEB theory? Sub questions could be: Can you have theory-free models, and when would they be useful? Can you use theories without models? Can you have mechanistic models without formal theory? How are parameters interpreted in theoretical and empirical models? When is it ok to modify models from theoretical expectation?
- TOPIC 2: Future developments – Starting points could be to read some of the comments to "Physics of Metabolic Organisation" by Jusup et al [19]. Patricia Holden – Galik & Forbes – Bas Kooijman - Pecquerie & Lika (but there are others). You can also look at the DEB research program, developments, applications pages from the DEB wiki.
- TOPIC3: evaluation of tele- and practical course with respect to learning objectives

The reporters will summarize the findings of these discussions in the plenary discussion. The chairmen reports the conclusions of the last evaluation discussion to the organizer. The composition of the groups will be a matter of self-organization, but we reshuffle after the first plenary discussion, again by self-organization.

9 School (1-6 April): Plenary discussions

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

10 School (1-6 April): Pet presentations (2H)

We ask successful participants to present their results briefly; experts giving comments. If time allows we will compare the parameter values and give a short presentation of the findings.

11 WORKSHOP (8-9 April):

There will be 4 main workshops:

11.1 DEB in ecotoxicology

11.1.1 Lectures

- Background and concepts (30 min)
- Lesson learned from NiMBios[4] working group (Roger Nisbet, 30 min)
- Case study on model-experimental cooperation[5] (30 min)

11.1.2 Moderated discussion

The workshops should enable us to make the link between theory and the concrete applications that we face on a daily basis in our research work. What approaches should be implemented in order to study the effect of environmental stress with DEB theory? What type of approach should be used to scale up the population? How should we reconcile spatial and temporal scales in our models? etc. These discussions, which will accompany the presentations and implementations, should be a forum for discussion and sharing around integrated modelling approaches.
Topics:

- Data needs for DEB models
- Why DEB models in ecotoxicology?
- How to strengthen model-experimental cooperation?

11.2 DEB for recontruction problems

11.2.1 Lecture "An introduction to Trajectory Reconstruction" (Laure Pecquerie 30 min)

- Otoliths
- Reconstructing environmental conditions

11.2.2 DEB in practice "Reconstruction of food intake from growth data" (2.5H)

Leader: Laure Pecquerie
Assistants: Gonçalo, Laure, Starrlight, Dina, Bas, Nina
Chap 4. Univariate DEB models, Kooijman 2010, presents 4 examples of "Trajectory reconstructions": reconstruction of food intake and body temperature from growth data, reconstruction of food intake from reproduction data and last reconstruction work from otolith data.
Trajectory reconstructions are useful and creative applications of the DEB theory, as many data sets (on growth or reproduction) do not provide adequate information about food intake and this information is often very hard to quantify experimentally.
In this workshop we will perform a practical reconstruction problem. We will be updating this documents with the background information and material that is needed prior to the start of the school.

11.3 DEB in Biophysical Ecology

11.3.1 Lecture "Biophysical Ecology" (Michael Kearney 1 H)

- Thermodynamic constraints
- Endotherm body temperature
- Predicting endotherm energy and water requirements
- Predicting climate niches

11.3.2 DEB in practice "Biophysical Ecology with NicheMapR "

- Guided exercise/lecture lead: Mike R Kearney
- Presentation of niche mapR
- Demo

11.3.3 Moderated discussion (30 min)

11.4 DEB in practice: individuals to populations to community

11.4.1 Lecture "Individuals to populations to community" (Bob Kooi 1H)

Introduction and discussion of the following types of population models:

- Densities vs numbers
- Processes vs events
- Deterministic vs stochastic

[4] Murphy et al., "Incorporating Suborganismal Processes into Dynamic Energy Budget Models for Ecological Risk Assessment."
[5] Sussarellu et al., "Oyster Reproduction Is Affected by Exposure to Polystyrene Microplastics."

- Continuous time vs discrete time
- Continuous state vs discrete state
- Ordinary differential equations vs Markov chain
- Population mean vs population variability
- Spatially homogeneous vs heterogeneous environment

Study of a simple predator-prey system. The classical model is the Rosenzweig-MacAthur model where the prey grows logistically. We formulate and analyse a mass balance model where the law of mass conservation is obeyed. In this model nutrients are modelled explicitly. A detailed analysis of the different model types illustrates their specific features with respect to dynamical behavior.

In case of deterministic models we will use the populations existence and a stability analysis showing dependence of the dynamical behavior on parameter values.

In case of stochastic models we use a stochastic simulation algorithm to obtain realizations in order to study the population variability.

11.4.2 DEB in practice " From individuals to populations: an introduction"

In this part of the workshop we wil go through a practical guided exercise, running code that is provided by the teacher.

11.4.3 Moderated discussion

We will discuss the problems and results of the guided exercise.

12 References

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