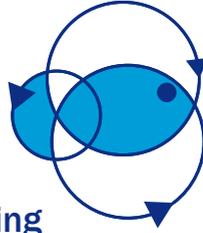


AIMEN

Innovative Approaches in
Marine Environment Modelling



August 19-23 2013

IUEM, Brest, France

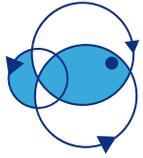


Supported by the Labex MER and CNRS, this thematic school aims at strengthening our knowledge and the understanding of the functioning of the marine ecosystems within the framework of global change. The development of new modeling approaches represents a critical innovation towards this end. The complexity of marine ecosystems represents a significant obstacle, which impedes our ability to evaluate their responses to natural and anthropogenic stressors. This complexity results from the large number of «actors» (virus, bacteria, plankton, particles, fish, benthic fauna, large predators,...), of interactions (which are mostly non linear) and of scale transfers, at spatial, temporal as well as at «functional» level (cell, individual, population, ecosystem).

Relying on theoretical and conceptual considerations of modern ecology and complex systems, this school aims to address these different levels of complexity. During the week, the different modeling approaches currently developed in the marine environment will be presented, discussed and assessed. With a strong training component, this school will allow us to critically examine these different approaches, exchange expertise, and facilitate interactions. Based on a shared diagnosis of the challenges to face, it will also help us to identify new types of models suited for the marine environment. We look forward to a stimulating week! Welcome to Brest!

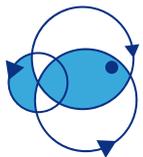
The Steering committee,

C. Bacher (Ifremer), C. Floc'h-Laizet (IUEM/UBO), A. François (IUEM/UBO), S. Herve (IUEM/UBO), A. Le Mercier (IUEM/UBO), L. Memery (IUEM/CNRS), M. Parenthoen (ENIB), L. Pecquerie (IUEM/IRD), L. Tito De Morais (IUEM/IRD)



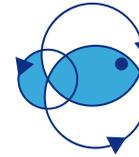
INVITED SPEAKERS

- K. H. Andersen (DTU Aqua, DE)
- F. Boschetti (CSIRO, AU)
- P-A. Braillard (IHPST, FR)
- J. Bruggeman (St John's college, Oxford, GB)
- W. Cheung (Univ. British Columbia, CA)
- Ø. Fiksen (University of Bergen, NO)
- G. Fussmann (Mc Gill, CA)
- C. Guill (Göttingen, NL)
- E. E. Hofmann (ODU, USA)
- C. Klausmeier (Michigan State Univ., USA)
- E. Litchman (Michigan State Univ., USA)
- A. Mc Kane (University of Manchester, UK)
- R. Nisbet (UCSB, USA)
- W. Porter (Univ. Wisconsin, USA)
- K. Rose (LSU, USA)
- M. Van Baalen (UPMC, FR)
- A. Voinov (Twente, NL)
- B. Ward (ENS, FR)



SCIENTIFIC COMMITTEE

- C. Bacher (Ifremer)
- L. Memery (IUEM/CNRS)
- M. Parenthoen (ENIB)
- L. Pecquerie (IUEM/IRD)
- L. Tito De Morais (IUEM/IRD)



PROGRAM

AIMEN targeted audience consists of young, as well as experienced researchers, wishing to broaden their expertise and knowledge in modeling approach, already acquainted with marine ecology.

The program is structured with five sessions of one day, each one being dedicated to a specific theme.

- Day 1: Functional biodiversity (J. Bruggeman, E. Litchman, B. Ward)
- Day 2: Relationships between individuals and populations (E. Hofmann, A. J. McKane, R. Nisbet)
- Day 3: Adaptation and evolution (Ø. Fiksen, W. Porter, M. Van Baalen)
- Day 4: Trophic interactions, complexity and emergence (F. Boschetti, C. Guill, G. Fussmann)
- Day 5: Complexity approached by «end-to-end» models ? (K. Andersen, W. Cheung, K. Rose)

The thematic school will consist of academic presentations, of studies of applications of modelling tools and concepts, and of debates and exchanges between the participants. Each day will follow the same pattern: three key lectures/conferences, informal presentations of the participants' work, and roundtables / discussions on specific scientific issues linked to the lectures. During the evenings of days 1, 2 and 4, presentations and debates on broad concepts are planned, and will be followed by informal debates.

Monday, August 19	
FUNCTIONAL BIODIVERSITY	
09:00	Welcome of participants
	Introduction to the thematic school
10:00	Plenary lecture 1 Jorn BRUGGEMAN (St John's college, Oxford) <i>On the behaviour of plankton communities: trade-offs and species diversity pull the strings</i>
11:00	Coffee Break / posters session
	Plenary lecture 2 Elena LITCHMAN (Michigan State Univ., USA) <i>Linking traits and ecological niches to predict eco-evolutionary responses of phytoplankton to global change</i>
12:00	
13:00	Lunch Break
14:00	Plenary lecture 3 Ben WARD (ENS, FR) <i>The paradox of the plankton: linking theory to global biodiversity, biogeography and ecosystem function</i>
15:00	7-min oral attendees presentations Attendees will present their scientific interest in 3/4 slides (~7' each presentation)
16:00	Coffee Break / posters session
17:00	Practical round tables (PR: paper review) Bruggeman: A group (PR), Litchman: B group (PR), Ward: C group (PR)
18:00	Break / posters session
19:00	Dinner
20:00	
21:00	Evening conference Christopher KLAUSMEIER (Michigan State Univ., USA) <i>Trait-based approaches to plankton ecology</i>
22:00	
23:00	Shuttle to Hotel

Tuesday, August 20	
FROM INDIVIDUALS TO POPULATIONS	
09:00	General discussion and report on the day-before roundtables
10:00	Plenary lecture 1 Eileen E. HOFMANN (ODU, USA) <i>Coupling across individuals, populations and human systems in marine ecosystem models</i>
11:00	Coffee Break / posters session
	Plenary lecture 2 Alan Mc KANE (Univ. of Manchester, UK) <i>From the microscale to the macroscale</i>
12:00	
13:00	Lunch Break
14:00	Plenary lecture 3 Roger NISBET (UCSB, USA) <i>Individual-based and structured population models based on dynamic energy budgets</i>
15:00	7-min oral attendees presentations Attendees will present their scientific interest in 3/4 slides (~7' each presentation)
16:00	Coffee Break / posters session
17:00	Practical round tables (PR: paper review / CW: Computing work) Hoffmann: A group (PR), Mc Kane: B group (PR), Nisbet: C group (CW)
18:00	Break / posters session
19:00	Dinner
20:00	
21:00	Evening conference Alexey A. VOINOV (ITC, Univ. of Twente, NL) <i>Model integration – from simple to complex, from brain to cloud</i>
22:00	
23:00	Shuttle to Hotel

Wednesday, August 21	
ADAPTATION AND EVOLUTION	
09:00	General discussion and report on the day-before roundtables
10:00	Plenary lecture 1 Øyvind FIKSEN (Univ. of Bergen, NO) <i>Modelling behaviour and life history strategies in marine organisms</i>
11:00	Coffee Break / posters session
12:00	Plenary lecture 2 Warren PORTER (Univ. Wisconsin, USA) <i>Connecting art and science to determine climate change effects on sea turtle nesting and oceanic distributions</i>
	Lunch Break
13:00	
14:00	Plenary lecture 3 Minus VAN BAALEN (UPMC, FR) <i>The ecology and evolution of spatially extended systems: cellular automata and analytical approximations</i>
15:00	7-min oral attendees presentations Attendees will present their scientific interest in 3/4 slides (~7' each presentation)
16:00	Coffee Break / posters session
17:00	Practical round tables (PR: paper review / CW: Computing work) Fiksen: A group (CW), Porter: B group (PR), Van Baalen: C group (PR)
18:00	Break / posters session
19:00	Dinner and social event in Brest (Océanopolis)

Thursday, August 22	
TROPHIC INTERACTIONS, COMPLEXITY AND EMERGENCE	
09:00	General discussion and report on the day-before roundtables
10:00	Plenary lecture 1 Fabio BOSCHETTI (CSIRO, AU) <i>The relation between mental and computer models: some experiment in the management of natural resources</i>
11:00	Coffee Break / posters session
12:00	Plenary lecture 2 Christian GUILL (IBED, Univ. of Amsterdam, NL) <i>Food webs made simple: The influence of body size on structure, dynamics, and functioning of complex trophic networks</i>
	Lunch Break
13:00	
14:00	Plenary lecture 3 Gregor FUSSMANN (Mc Gill, CA) <i>Eco-evolutionary dynamics in aquatic communities: from mathematical to organismal models</i>
15:00	7-min oral attendees presentations Attendees will present their scientific interest in 3/4 slides (~7' each presentation)
16:00	Coffee Break / posters session
17:00	Practical round tables (PR: paper review) Boschetti: A group (PR), Guill: B group (PR), Fussmann: C group (PR)
18:00	Break / posters session
19:00	Shuttle to Hotel - Dinner
20:00	
21:00	Evening conference
22:00	Pierre-Alain BRAILLARD (IHPST, FR) <i>Some philosophical remarks on the use of complex modelling in biology</i>

Friday, August 23

END-TO-END MODELLING

09:00	General discussion and report on the day-before roundtables
10:00	Plenary lecture 1 Ken Haste ANDERSEN (DTU Aqua, DK) <i>Size- and trait-based modelling of fish communities for the ecosystem approach to fisheries management</i>
11:00	Coffee Break / posters session
12:00	Plenary lecture 2 William CHEUNG (Univ. British Columbia, CA) <i>Detecting and projecting climate change effects on marine fisheries</i>
13:00	Lunch Break
14:00	
15:00	Plenary lecture 3 Kenneth ROSE (LSU, USA) <i>End-to-End modeling of marine ecosystems: can the people and data keep up with the computers?</i>
16:00	Practical round tables (PR: paper review / CW: Computing work) Cheung: A group (PR), Andersen: B group (CW), Rose: C group (PR)
17:00	Coffee Break / posters session
18:00	General discussion and report on the afternoon roundtables
	General discussion and conclusion of the school
19:00	Final address and end of AIMEN

Poster sessions

Belharet Mokrane

An approach for the modelling of radioactive cesium transfer in the northwestern pacific plankton using a simplified biological compartmental model coupled with an ecosystem model and a model of dispersion

Ferreira Sofia

Estimating phytoplankton phenology metrics from noisy, gappy data

Ghyoot Caroline

Modelling mixotrophy in eutrophied estuarine and coastal ecosystems

Holt Rebecca and **J**ørgensen Christian

Climate-Induced Adaptations of Behaviour and Life History for Atlantic Cod

Kenitz Kasia

Generating and sustaining phytoplankton diversity: exploring the effect of physical forcing changes

Prowe Friederike

Zooplankton feeding traits and community composition in a global ecosystem model

Ubertini Martin

Determinism of larval recruitment of oyster *Crassostrea gigas* in the Mediterranean: the case of the Thau lagoon

Vaes Tom

Colorful diversity of phytoplankton: costs and benefits of photosynthetic pigments

Oral presentations program

Monday 19	Tuesday 20	Wednesday 21	Thursday 22
Atkins	Alexandridis	Belharet	Blanchard
Ayata	Chia	Brochier	Cotté
Cadier	Holt	Lample	Cugier
Desmit	Lorkowski	Lindemann	Ferreira
Fontaine	Moreno	Politikos	García-García
Ghyoot	Murphy	Ubertini	Grosse
Monteiro	Prowe	Vaes	Jacobsen
Orchowska	Sainmont	Xia	Kenitz
Stec	Sevinc	Yakan Dundar	Koenigstein
Stomp	Smeti	Zablotski	Stegert
Terseleer Lillo			

Practical round tables groups

A Group	B Group	C Group
Alexandridis	Ayata	Blanchard
Atkins	Ghyoot	Politikos
Belharet	Grosse	Prowe
Brochier	Cadier	Sainmont
Chia	Kenitz	Smeti
Cotté	Lample	Stec
Cugier	Lindemann	Stegert
Desmit	Lorkowski	Stomp
Ferreira	Monteiro	Terseleer Lillo
Fontaine	Moreno	Ubertini
García-García	Murphy	Vaes
Holt	Orchowska	Xia
Jacobsen	Sevinc	Yakan Dundar
Koenigstein		Zablotski



PLENARY SESSIONS ABSTRACTS

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- 14 Linking traits and ecological niches to predict eco-evolutionary responses of phytoplankton to global change - *Elena Litchman*
- 15 The paradox of the plankton: linking theory to global biodiversity, biogeography and ecosystem function - *Ben Ward*,
- 16 Trait-based approaches to plankton ecology - *Christopher Klausmeier*
- 17 Coupling across individuals, populations and human systems in marine ecosystem models - *Eileen E. Hofmann*
- 18 From the microscale to the macroscale - *Alan J. McKane*
- 19 Individual-based and structured population models based on dynamic energy budgets - *Roger M Nisbet*
- 20 Model integration – from simple to complex, from brain to cloud - *Alexey Voinov*
- 21 Modelling behaviour and life history strategies in marine organisms - *Øyvind Fiksen*
- 22 Connecting art and science to determine climate change effects on sea turtle nesting and oceanic distributions - *Warren Porter*
- 23 The ecology and evolution of spatially extended systems: cellular automata and analytical approximations - *Minus Van Baalen*
- 24 The relation between mental and computer models: some experiment in the management of natural resources - *Fabio Boschetti*

- 26 Food webs made simple: The influence of body size on structure, dynamics, and functioning of complex trophic networks - *Christian Guill*
- 27 Eco-evolutionary dynamics in aquatic communities: from mathematical to organismal models - *Gregor Fussmann*
- 28 Some philosophical remarks on the use of complex modelling in biology - *Pierre-Alain Braillard*
- 29 Size- and trait-based modelling of fish communities for the ecosystem approach to fisheries management - *Ken Haste Andersen*
- 30 Detecting and projecting climate change effects on marine fisheries - *William W.L. Cheung*
- 31 End-to-End modeling of marine ecosystems: can the people and data keep up with the computers? - *Kenneth A. Rose*

On the behaviour of plankton communities: trade-offs and species diversity pull the strings

Jorn Bruggeman
St John's college, Oxford, UK

Species diversity plays a key role in regulating ecosystem behaviour. But how should it be modelled? In this session I will look at approaches applied to plankton. Over the past three decades, bulk nutrient-phytoplankton-zooplankton-detritus models have grown into detailed Plankton Functional Type models. These explicitly describe many natural species, but they are complex, expensive to run, and difficult to constrain. Recent “trait-based”, “self-assembling” or “adaptive” approaches do this differently: they summarize species diversity in terms of a few key traits such as size, and allow these to control all aspects of physiology. This makes it possible to build diverse communities by effectively throwing together species with different trait values. In variable environments, these model communities can show realistic changes in species composition and diversity. But what regulates these changes? I will look at the role of trade-offs in selecting for particular species, and the role of functional diversity in regulating the rate of succession. Further, I will discuss how these two ingredients can be combined to build a compact, “adaptive dynamics” model that preserves the main features of species diversity, while considerably reducing model complexity. As proof of principle, I look at seasonal and interannual change in phytoplankton size in Lake Constance, for which a detailed 30-year record of species composition is available.

Linking traits and ecological niches to predict eco-evolutionary responses of phytoplankton to global change

Elena Litchman
Michigan State University, USA

Phytoplankton are major primary producers in aquatic ecosystems and are sensitive to various aspects of global environmental change. They can respond through phenotypic plasticity, species sorting, genetic adaptation, or a combination of these processes. I will present conceptual, experimental and theoretical ways to predict different phytoplankton responses to global change. Using phytoplankton ecological niches to predict their responses to multiple environmental stressors is a promising new approach. Functional traits of phytoplankton, such as resource utilization traits and tolerance curves for various environmental factors like temperature, can be used to define niches along major axes. Characterization of pairwise and higher dimension trade-offs among traits should help predict possible niche changes along multiple dimensions simultaneously. The potential for evolutionary responses to global change can be assessed using evolution experiments with individual strains, as well as in communities, because the responses may depend on the presence of competitors, grazers and parasites. The evolutionary pressures induced by multiple stressors may have interactive effects and, thus, should be investigated simultaneously. Novel models of trait evolution in a community context should provide additional insights into potential adaptation trajectories under diverse global change scenarios.

The paradox of the plankton: linking theory to global biodiversity, biogeography and ecosystem function

Ben Ward,
ENS, France

How it is possible for a large number of species to coexist in an environment, when all competing for the same limited resources? This question has been asked, and answered, many times by plankton ecologists over the past half-century. I will talk about the conceptual basis of some of the proposed solutions, and will then go on to look at their large-scale implications for ecosystem function in global ocean models. Topics will include multiple limiting resources; environmental heterogeneity; plankton size; trade-offs between growth, resource acquisition and storage; grazer avoidance and mixotrophy.

Trait-based approaches to plankton ecology

Christopher Klausmeier
Michigan State University, USA

Ecological communities are complex, due to the large number of species interacting in a heterogeneous environment. Recently it has been suggested that one way to peer through this complexity is to view communities through a trait-based lens. I will present an overview of different trait-based modeling approaches, give some examples of how they have been used, describe how they can be extended to include spatial and temporal heterogeneity, and outline future challenges.

Coupling across individuals, populations and human systems in marine ecosystem models

Eileen E. Hofmann
ODU, USA

Understanding and projecting responses of marine ecosystems to changing climate conditions and direct human impacts, such as fisheries, requires integrated ecosystem analyses at scales previously unexplored. This lecture will use examples from existing marine ecosystem models that illustrate coupling of physical and biological processes at a range of scales and discuss limitations inherent in particular model structures. The ecological and modeling challenges in predicting the responses of marine ecosystems to change will be discussed within the context of three focus areas. The first focus area is development of fundamental understanding of the factors that determine the structure and function of the food webs at multiple scales. Ecological research is often centered on key species or localized systems, a tendency which is reflected in existing food web and ecosystem models. To build on this, a systematic analysis of regional food web structure and function is required. The second focus area is development of a range of mechanistic models that vary in their resolution of ecological processes, and consider links across physical scales, biogeochemical cycles and feedbacks. The third focus area is development of methodologies for scenario testing across a range of trophic levels of the effects of past and future changes, which will facilitate consideration of the underlying complexity of interactions and the associated uncertainty. Modeling approaches that are developed within a scale-based framework that emphasizes both physical and ecological aspects will be discussed. The lecture will end with a discussion of coupling of marine ecosystem models to human system models.

From the microscale to the macroscale

Alan J. McKane
University of Manchester, UK

This lecture will be concerned with the setting up of individual-based models (IBMs), and the approximations which can be used to analyse these models. Since they involve the interaction of the basic entities of the system (individuals) they are termed ‘microscopic’ and are typically in a good form to numerically simulate, but not to mathematically analyse. We discuss how a more coarse-grained description of the system can be obtained at the ‘mesoscale’, and how the average behaviour is found on the ‘macroscale’, and how these forms can be more easily analysed. The emphasis will be on simple, generic examples to illustrate the ideas and concepts, rather than on specific detailed models, and will provide an overview of the relationship between IBMs and population-level descriptions.

Individual-based and structured population models based on dynamic energy budgets

Roger M Nisbet
UCSB, USA

This lecture will review two families of model that relate population dynamics to the physiology and behavior of individual members of a population. Individual-based models are computer simulations of a collection of organisms, characterized by individual or “i-state” variables such as age or mass, and interacting with a shared environment. Structured population models describe the dynamics of the distribution of individuals in a very large population among its i-states, for example its age or size structure. Good examples of both approaches make use of bioenergetic or Dynamic Energy Budget (DEB) models. DEB models describe the rates at which individual organisms assimilate energy and elemental matter, and utilize them for growth, development and reproduction. Because DEB theory is founded on general principles, it has the potential to increase understanding of population-level effects of environmental stress for a wide range of organisms and environmental conditions.

Model integration – from simple to complex, from brain to cloud

Alexey Voinov
University of Twente, NL

There is much interest in model reuse and integration, which supposedly should help to take into account more factors and therefore better explain how systems work. When models are treated as software components only, there is an increased risk of generating run-away complexity of integrated models, and producing ‘integronsters’ - constructs that are perfectly valid as software products but ugly or even useless as models. One possible remedy is to learn to use the data that are available for module calibration as an intermediate linkage tool against which we check the information flow between modules. Engaging stakeholders in the modeling process can be another efficient way to keep model complexity under control and to produce better and more useful models. Participatory modeling is a good way to synchronize and integrate stakeholder knowledge, and to build more consensus, more ‘buy-in’ into the modeling results. Models provide the necessary formalism to describe and integrate stakeholders perceptions and system conceptualizations. The challenge is to develop tools and methods to integrate qualitative stakeholder models with quantitative computer simulations.

Modelling behaviour and life history strategies in marine organisms

Øyvind Fiksen
University of Bergen, Norway

This lecture will give an introduction to the use of optimality theory and modelling methods in behavioural ecology and life history theory. I will explain how to develop a dynamic programming model and how the predictions from such models should be interpreted, and why they are useful. In addition, I will briefly contrast this approach with individual-based models of organisms with behavioural traits. The focus will be on habitat selection and energy allocation in marine organisms, in particular zooplankton and fish.

Connecting art and science to determine climate change effects on sea turtle nesting and oceanic distributions

Warren Porter
University of Wisconsin, USA

We illustrate how digital 3D art has been used to create virtual lean and fat animated animals that can be inserted into computational fluid dynamics to obtain drag and heat transfer properties, then those results can be inserted into Niche Mapper™ to compute energetics, behavior and distributions on land and at sea for current and future climate scenarios. Tests of the virtual computational models against physical models in the laboratory and field will be described.

The ecology and evolution of spatially extended systems: cellular automata and analytical approximations

Minus Van Baalen
UPMC, France

Space is an attribute of ecological systems but often simplified away by modelers because few mathematical tools are available. Traditionally, ecologists have modeled spatial dynamics using a metapopulation approach where a population is subdivided in many discrete subpopulations. In reality, many systems are distributed over a much more continuous spatial domain, and these are difficult to analyse. Diffusion models can be used but they have some serious drawbacks, in particular when the discreteness of individuals counts and it often does in ecology. With the increasing availability of cheap processing power, researchers are using cellular automata to simulate spatial dynamics. Cellular automata have the advantage of being easy to set up, can accommodate a large variety of ecological systems. Their analysis poses some difficulties, though, limiting the general lisibility of the results obtained using them. Here I will discuss mathematical techniques adapted from theoretical physics, called pair approximation models or correlation dynamics models, that can be used to obtain deeper insight in the ecology and evolution of spatially extended systems.

The relation between mental and computer models: some experiment in the management of natural resources

Fabio Boschetti
CSIRO, Australia

I will address 3 closely related issues: a) what affects the decision makers' and stakeholders' understanding, acceptance, trust, and thus willingness to act upon the results of ecological models, b) how these cognitive processes can be incorporated into ecological models, c) what complex, self-referential processes arise from their relations. We will see that these interactions can lead to the emergence of causal processes with considerable impact in the real world. For each of these issues I will discuss the results we obtained from experiments run with decision makers and stakeholders related to fishery and marine conservation projects.

a) Ecological modeling is increasingly used to support decision making as well as community consultation. In these settings, effective understanding of scientific results can be affected by barriers which have more to do with human cognition and psychology than the complexity of the problem at hand. For example, while for modellers model acceptance usually hinges on data accuracy, model reliability, and problem uncertainty, in a social context the acceptance of model results also depends on context, type of problem, implications of the model, characteristics of the audience and stakeholders, the charisma and reputation of the modeller, and much else. We report on a number of studies we carried out with local decision makers and stakeholders related to marine park and fishery management, as well as on our development of a survey tool specifically designed for environmental problems in which modelling is employed as a part of the decision making process.

b) It follows that for some purposes ecological models may need to include social and decision making processes. While physical, biological and ecological knowledge is usually understood as external to the systems under study (our understanding of celestial mechanics does not affect the motion of the planets), this is not necessarily true for knowledge related to human behaviour. In a human and social context, the mental models used to represent a system (even 'wrong' mental models) can affect the system itself, via the human actions they induce. This self-referential process is very difficult to model but has strong impact on the real world as clearly showed in the recent financial crisis and climate change debate.

c) Usually, ecological models are seen as virtual laboratories, where we can carry out experiments which would be impossible or too difficult to perform in the real world. How do we reconcile the apparent objectivity of such models with the subjectivity of the mental models people use to guide their behaviour, if these need to be incorporated in the numerical models? One possible avenue is to consider numerical models as formalisation of mental models. This brings numerical and mental models on the same level and allows us to compare them. Numerical models can circumvent the logical fallacies humans often display and can provide a check of the consistency of human decision making. We describe a number of experiments in which comparison between mental models and numerical models have been carried out and discuss the possible implications for communicating the results of ecological modelling. Also, viewing ecological models as formalised mental models implies that ecological models too can have a causal power in the real world. This leads to the emergence of yet another self-referential process since the results of a numerical model can affect the decision makers' mental models which in turn can affect the real world. We discuss an experiment we recently carried out by explicitly asking responders' to parameterise a numerical model and estimate the model results as well as their acceptance of the model.

Food webs made simple: the influence of body size on structure, dynamics, and functioning of complex trophic networks

Christian Guill
University of Goettingen, Germany

Trophic interactions are key to our understanding of the functioning of ecological communities. In my lecture I consider large and complex interaction networks, or food webs, that are formed by countless trophic interactions between the species of a community. Instead of characterising the dynamics of pairs of interacting species one by one, it is more instructive to identify general mechanisms that determine structure and stability of the entire networks. A key characteristic of species is their body size, as it determines to a large extent which species they prey on and to whom they are prey. In addition, species' metabolic rates (e.g. respiration or maximum ingestion) also depend on their body size. These rates control the strength of trophic interactions and thus the population dynamics of the species. The latter, in turn, determines which species of the community persist and which go extinct. In natural communities, predators are usually larger than their prey. This particular size structure of the trophic relations is in part due to mechanical constraints in the process of capturing and ingesting prey, but it also leads to dynamically stable communities. In fact, the stabilising forces of large predator-prey size ratios are so strong that even in communities with randomised size-ratios clear size-structured food webs emerge dynamically.

Eco-evolutionary dynamics in aquatic communities: from mathematical to organismal models

Gregor Fussmann
McGill University, Canada

There is a growing realization that ecological dynamics in complex communities are shaped by the interplay of ecological and evolutionary processes. I introduce several mathematical modelling approaches to eco-evolutionary dynamics, i.e. population and community models that allow for rapid evolution. Eco-evolutionary models often make different predictions than purely ecological (or evolutionary) models, which demands empirical testing and validation of these models. I present the history of testing eco-evolutionary theory with plankton-based, organismal models; the experimental system for which there is greatest progress to date. The ultimate question is whether rapid, contemporary evolution plays a major role for the dynamics of real ecosystems. A promising avenue of concrete research in this direction is the idea of "evolutionary rescue". Under this framework, populations and species that cannot migrate need to adapt locally to avoid extirpation due to rapid environmental change. I present recent theoretical and empirical progress in this line of research, particularly with respect to the adaptive dynamics and rescue potential of complex communities.

Some philosophical remarks on the use of complex modelling in biology

Pierre-Alain Braillard
IHPST, France

Mathematical models and computer simulations have recently become widespread in biology. My goal in this talk is to discuss their different roles in the analysis and explanation of complex biological phenomena. I will focus on three issues that are particularly interesting from a philosophical point of view. First, I will describe the historical tension we see in biology concerning the use of simplified mathematical models to represent and explain complex phenomena. While some biologists have defended their use for a long time, many have remained highly sceptical. This reflects different explanatory styles in scientific practice. A second related point concerns the differences between models developed to address particular scientific questions and models whose goal is to formulate general principles. A third question, which has received diverging answers in recent debates, is whether it is legitimate to consider computer simulations as a kind of experiment. This issue is central to better grasping the contribution of computational modelling to biology.

Size- and trait-based modelling of fish communities for the ecosystem approach to fisheries management

Ken Haste Andersen
DTU AQUA, Denmark

The ecosystem approach to fisheries management requires that managers develop the ability to make impact assessment of management actions on the level of the entire ecosystem, and not just on a single species. I will introduce a modelling framework that is specifically aimed at making impact assessment of fishing for an entire fish community. The framework is based on size (weight or length) of individuals and on their traits, in this case asymptotic size or size at maturation. The application of the model framework will be illustrated with examples of trophic cascades, «balanced fishing» and the maximum yield that can be extracted from the ecosystem in terms of protein or rent while respecting constraints of conservation. The model framework has been implemented as web applications for a single species: <https://www.stockassessment.org/spectrum/> and for an entire community: <http://130.226.135.24/SSC>.

Detecting and projecting climate change effects on marine fisheries

William W.L. Cheung
*University of British Columbia,
Canada*

How climate change affects marine biodiversity and fisheries are important questions for ocean management and conservation. Analyzing major marine fishes and invertebrates stocks in the world with simulation models and landings data, we show that there will be large-scale changes in species composition, pattern of marine biodiversity and redistribution of potential fisheries catch. We also project that marine ecosystems and fisheries will be further impacted through changes in the physiology and life history of fishes and shellfishes, with the level of such impacts. Ocean acidification and reduced oxygen levels in the ocean may substantially increase the rate of distributional shifts and reduce the potential fisheries yield. These findings form the basis for the determination of ways to formulate fisheries policies in the future under climate change.

End-to-End modeling of marine ecosystems: can the people and data keep up with the computers?

Kenneth A. Rose
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I will first describe what I mean by end-to-end modeling, the reasons why end-to-end modeling is needed and gaining popularity, and the major challenges with developing and applying end-to-end models. Then I will present an example of a 3-D model of sardine and anchovy in the California Current that combines the ROMS hydrodynamics model, the NEMURO NPZ model, individual-based fish population models, and a fishing fleet model. I will use the example to illustrate how such models are developed, coded, and how their output is interpreted. I will conclude with a discussion of the future directions I envision for end-to-end modeling.

Notes



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