EUROPEAN SCIENCE FOUNDATION
SETTING SCIENCE AGENDAS FOR EUROPE

RESEARCH NETWORKING PROGRAMME

BODY-SIZE AND ECOSYSTEM DYNAMICS: INTEGRATING PURE AND APPLIED APPROACHES FROM AQUATIC AND TERRESTRIAL ECOLOGY TO SUPPORT AN ECOSYSTEM APPROACH (SIZEMIC)

Standing Committee for Life, Earth and Environmental Sciences (LESC)

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Cover picture: Large seal and approaching small fish prey

SIZEMIC logo design by Kira Askaroff

Introduction

"The ecosystem approach is based on application of appropriate scientific methodologies focused on levels of biological organisation, which encompass the essential structure, processes, functions and interactions among organisms and their environment."

United Nations Convention on Biodiversity (1992)

Body size and species identity both contribute to the complex webs of interaction that determine the structure and function of ecosystems. The SIZEMIC Research Networking Programme will attempt a synthesis of size- and species-based approaches for describing structure and energy flux in the food webs that comprise ecosystems and seek to understand how the properties of individuals lead to observed patterns of size structure and diversity. This synthesis, building on recent theoretical developments in aquatic and terrestrial ecology, will be used to develop and test size-based models that might be used to assess and monitor the impacts of human activities on ecosystems. The network will provide a focus for collaboration between theoretical and applied ecologists working on terrestrial and aquatic ecosystems and provide opportunities for young European scientists to work across existing research boundaries.

In aquatic ecosystems, the principle primary producers are small unicellular algae, and these support strongly size structured food-chains where most predators are larger than their prey (Dickie *et al.*, 1987). Conversely, in terrestrial ecosystems, most of the primary producers are large and create habitat architecture. In aquatic ecosystems, most species begin life as larvae feeding at the base of food chains, but can end life as large terminal predators. Lifetime weight increases of five orders of magnitude and more are typical of many species, and a fast growing species may begin life as a prey item for other species only to become the main predator on the same group of species within one year (Boyle and Bolettzsky, 1996). In terrestrial ecosystems, the growth in weight between juvenile and adult stages is usually less than in aquatic ecosystems, although many species do exhibit ontogenetic changes in diet. Body size and species identity together contribute to the complex webs of interactions within ecosystems (Cohen *et al.*, 2003).

Ecologists have developed a number of ways to think about these webs of interactions. One perspective comes from the traditional study of food webs which aggregates species with similar feeding habits into nodes in a network of feeding relations: energy moves through the system by transfer from one node to another (Dunne *et al.*, 2004; Brose *et al.*, 2005). The focus here is on how the flows of resources through the network determine their macroscopic properties such as topology and stability. There is often a tacit assumption that body size is fixed within species in this work; if size structure is present, it is typically in the orderly process by which species with large body size eat those with small size (Cohen *et al.*, 1993). In addition, average species body size may be used to determine interaction rates in the food web (Brose *et al.*, 2006).

A contrasting perspective focuses on the community-level biomass distribution in different body size classes and ignores species identity altogether. These approaches have been inspired by some remarkable empirical regularities in abundance – body mass relationships in ecosystems, irrespective of species identity (Brown and West, 2000; Gaston and Blackburn, 2000), for example, from phytoplankton to whales in the sea (Kerr, 1974). The discovery of such regularities points to aspects of ecosystem structure determined by body size, rather than by taxonomic identity (Belgrano *et al.*, 2005). From this perspective, energy is thought of as moving through the system as a result of growth of individuals when they eat smaller individuals (Kerr and

Shoal of snappers on coral reef

Dragonfly and prey

Dickie, 2001; Benoit and Rochet, 2004). The focus here is on how microscopic processes, such as the size of prey items consumed and the growth in body size, determine the emergent spectrum of body sizes in the ecosystem.

An intermediate approach uses population and small community models that account for both species identity as well as intra- and inter-specific size distrbutions. These so-called size-structured models are based on a mechanistic description of individual life history, including growth, ontogenetic development, reproduction and mortality, and aim at explaining community dynamics and structure in terms of these individual-level processes (De Roos *et al.* 2003). The strength of these models is their explicit recognition of both the individual and population level and the tight link and feedbacks between processes at these two levels of biological organization. In contrast, these models have only been used to analyze the dynamics of communities with a small number of species.

The different frameworks — traditional food webs, size-structured population models and biomass size spectra — focus on different aspects of biological communities, which in reality all play an important role. Real food webs comprise many species and their dynamics are determined not only by species identity, but also by individual growth in body size, inter- and intra-specific variation in size Theorists need to work towards a synthesis of the approaches.

Further development of these approaches is essential to understand the links between population, community and ecosystem structure, function and process and how these community aspects originate from the ecological processes at the level of individual organisms.

The running period of the ESF SIZEMIC Research Networking Programme is for four years from May 2007 to May 2011.

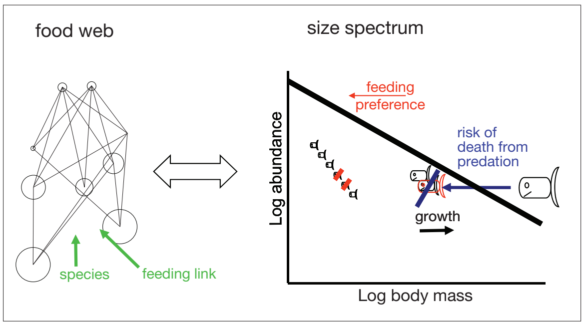

Figure by Richard Law (University of York)

Schematic illustration of two branches of theory used in SIZEMIC: a traditional foodweb and a size spectrum. In traditional food webs the species have fixed body sizes and the species identity determines foodweb links. In a size spectrum individuals start at a small size and they either grow or die over time. Their food web interactions change with their body size.

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Aims

SIZEMIC aims to put in place an interdisciplinary forum to develop the research agenda enabling theoretical and applied ecologists to develop size-based approaches for understanding ecosystem dynamics and the responses of ecosystems to human impacts. Workshops will allow participants from across Europe and working in 'theoretical' and 'applied' science to share their knowledge and to develop new theory and new methods for applying size-based approaches to management problems. Participation by PhD students and new post-doctoral researchers will help the next generation of European scientists to transcend the boundaries between 'pure' and 'applied' science that result from the existing institutional divides (for example between universities, research institutes and government science laboratories). In the longer-term, the collaboration between 'pure' and 'applied' science will help to support Europe in applying an ecosystem approach to environmental management, a focus of emerging European policy (e.g. 6th Environmental Action Programme, the emerging Marine Strategy Directive).

In sum, the proposed network will:

- Facilitate the exchange of ideas and data;
- Provide a forum from which theoretical and applied ecologists can develop new approaches for understanding ecosystem dynamics and the responses of ecosystems to human impacts;
- Generate opportunities for the current and next generation of European scientists to develop cross-disciplinary research collaborations.

Planned Activities

The network activities will be comprised of a series of workshops, a summer school, along with travel grants to fund short-term and long-term exchanges between researchers. Calls for proposals will be circulated in due course.

The network plans to hold workshops that allow several small working groups to meet at the same time, tackling different avenues of the research required in this area. Several themes comprise the core of the SIZEMIC research agenda, although these are open and may change as new themes and activities are expected to arise once the network progresses and develops.

Natterjack Toad (*Epidalea calamita*) eating worm

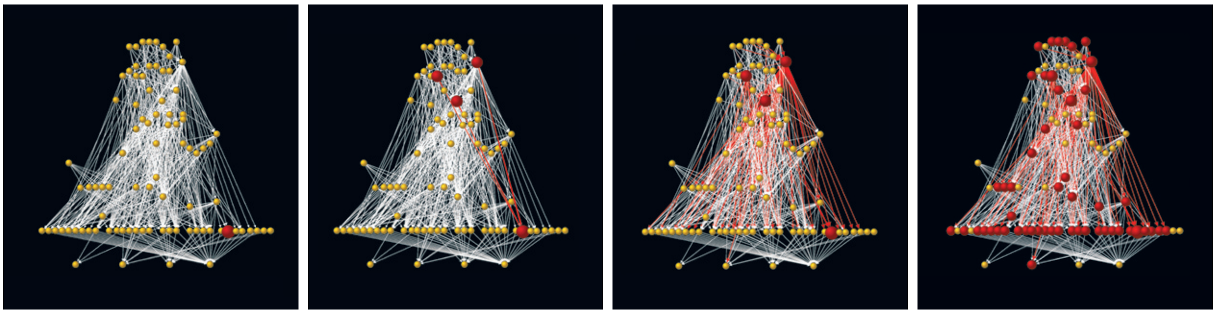
To develop the areas of theoretical and applied research of interest to SIZEMIC, four core research themes were originally proposed to be the focus of each workshop.

Workshop 1 – Developing a dialogue. Discussion of size- and species-based approaches for describing structure and energy flux in ecosystems. Identification of specific research topics within SIZEMIC.

Workshop 2 – The fine-scale processes. Detailed drivers of size-based food web interactions (including properties of individual organisms, such as preferred diets, handling times of prey, and energetics of body growth).

Workshop 3 – Coexistence of species in size spectra. Links between biodiversity and size structure in ecosystems: coexistence of species in size spectra

Workshop 4 – Human impacts on size-structured food webs. Use of size-based models to predict the effects of human-induced change on ecosystem structure and function.



Ythan Estuary food webs (63.2% of all species lie within two links)

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  Ministry of Education and Science, Spain
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  Swedish Research Council, Sweden
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  United Kingdom

Steering Committee

Richard Law (Chair)
Department of Biology
University of York
PO Box 373
York YO10 5YW • United Kingdom
Tel: +44 1904 328586
Fax: +44 1904 328505
Email: RL1@york.ac.uk

Ken Andersen
Danish Institute for Fisheries Research
Dept. of Marine Fisheries
Charlottenlund Slot
2920 Charlottenlund • Denmark
Tel: +45 3396 3300
Email: kha@difres.dk

Tom Battin
Department of Freshwater Ecology
University of Vienna
Althanstr. 14
1090 Vienna • Austria
Tel: +43 1 4277 54350
Fax: +43 1 4277 9542
Email: tom.battin@univie.ac.at

Carlos M. Duarte
Instituto Mediterráneo de Estudios Avanzados
Univ. Illes Balears
C/Miquel Marqués 21
07190 Esporles, Mallora • Spain
Tel: +34 971 611725
Fax: +34 971 611761
Email: carlosduarte@ifisc.uib.es

Bo Ebenman
Department of Biology
Linköpings University
581 83 Linköping • Sweden
Tel: +46 13 281 794
Fax: +46 13 282 611
Email: boebe@ifm.liu.se

Mark Emmerson
Environmental Research Institute
University College Cork
Lee Road
Cork • Ireland
Tel: +353 21 490 1951
Fax: +353 21 490 1932
Email: m.emmerson@ucc.ie

Tom Moens
Department of Biology
University of Ghent
Krijgslaan 281/S8
9000 Gent • Belgium
Tel: +32 9 264 8524
Fax: +32 9 264 8598
Email: tom.moens@ugent.be

Otso Ovaskainen
Department of Biological
and Environmental Sciences
University of Helsinki
Viikinkaari 1 • PO Box 65
00014 Helsinki • Finland
Tel: +358 9 191 57924
Fax: +358 9 191 57694
Email: otso.ovaskainen@helsinki.fi

André M. de Roos
Institute for Biodiversity
and Ecosystem Dynamics
University of Amsterdam
PO Box 94084
1090 GB Amsterdam • The Netherlands
Tel: +31 20 525 7747
Fax: +31 20 525 7754
Email: A.M.deRoos@uva.nl

Angheluta Vadineanu
Department of Systems Ecology
and Sustainablility
University of Bucharest
Splaiul Independentei, 91-95
Bucharest, RO 050095 • Romania
Tel: +40 21 315 1871
Fax: +40 21 315 1871
Email: anvadi@bio.bio.unibuc.ro

Programme Coordinator

Julia Blanchard
Centre for Environment, Fisheries & Aquaculture
Science (CEFAS)
CEFAS Lowestoft Laboratory
Pakefield Road
Lowestoft
Suffolk NR33 0HT • United Kingdom
Email: julia.blanchard@cefas.co.uk

ESF Liaison

Bernard Avril
Science

Ellen Degott-Rekowski
Administration

Life, Earth and Environmental Sciences Unit
(LESC)
European Science Foundation
1 quai Lezay-Marnésia • BP 90015
67080 Strasbourg cedex • France
Tel: +33 (0)3 88 76 71 78 (Science)
Tel: +33 (0)3 88 76 71 06 (Administration)
Fax: +33 (0)3 88 37 05 32
Email: sizemic@esf.org

For the latest information on this Research Networking Programme consult the SIZEMIC websites:
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EUROPEAN SCIENCE FOUNDATION
SETTING SCIENCE AGENDAS FOR EUROPE

1 quai Lezay-Marnésia | BP 90015
67080 Strasbourg cedex | France
Tel: +33 (0)3 88 76 71 00 | Fax: +33 (0)3 88 37 05 32
www.esf.org

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