Report of the PHYTBACK kick-off meeting

Time: the mornings of 25 and 26 october 2010 (09:00-13:00)
Place: Ecole Normale Supérieure, CERES-ERTI meeting room, 24 rue Lhomond, Paris 5th
See also the PDFs of the presentations.

Participants:

- *From MIT*: Mick Follows
- *From Bioemco*: Eric Edeline, Gérard Lacroix
- *From Molecular Plant Biology*: Chris Bowler, Leila Trichine, +postdoc in the lab (name?)
- *From Ecology & Evolution*: Regis Ferrière, Silvia De Monte, Stephane Legendre, Boris Sauterey, David Claessen. Andres Lopz-Sepulcre, a postdoc in the lab, participated as well.
- *From LOCEAN*: Francesco d'Ovidio

Objectives

The kick-off meeting had two main objectives:

- To get to know each other and each other's work, experience, background, skills, etc, in particular the aspects relevant to our common project. To find out our expectations for the Phytback project.
- To discuss how to kick off the research
    - Precise research questions for the different tasks (overall goal and first steps to take)
    - Technical issues (modelling, experiments)
    - Collaboration issues: coordination of modelling & experimental efforts

The meeting

During the warming up, some issues were discussed over coffee (here are the keywords only):

- Chris: How does MITgcm compare to other models?
    - Regis: should we include other models in our Phytback project?
- Eric: should we test the MITgcm further by running it with predators (of the zooplankton)?
    - Mick: this will affect the dynamics in the subtropics. Blooms will be affected, which are based on a decoupling of phytoplankton and their predators.
- Acclimation vs plasticity
    - "Evolvability" (Eric)
    - Epigenetics & reversibility
    - Plasticity vs epigenetics? Is plasticity adaptive?
- Eric poses the question of the usefulness of adaptive dynamics vs other methods, in particular in the case of polygenetic traits, for which the quantitative genetics framework could be more suitable.
- Mick raises the issue of colony formation.
    - Silvia mentions the work on Volvox (freshwater) and the relation to the evolution of multicellularity
    - Francesco: mucus visible from space (sat)
    - Regis: link to the evolution of cooperation
- Size & shape co-evolution
- Chris: (1) sex in diatoms, size-dependent. Polymorphism may be less important ecologically. (2) Pathogenicity, virus attacks diploid only. Haploids survive

The kickoff

First, David gave an overview of the Phytback project. See David's slides (PDF) "kickoff-intro-final.pdf". Followed by presentations of the participants themselves.

Gérard Lacroix
Key words of his presentation of his work: stoichiometry, food webs, *Scenedesmus* (colony formation depends on stoichiometry, different strategies under P or N limitation, different colony behaviour). The ANR project PULSE (peri-urban lake … society … environment): studying the link between environmental change and communities in lakes in Ile de France. Focus on nutrients, fish, impact of CO2 change. Experiments at Foljuif and mesocosms at Creteil. Possibility of fruitful exchange & collaboration with PHYTBACK.

Eric Edeline
Did his PhD on eels. Migration vs non-migration as a function of energy contents (intake?); a threshold reaction norm with a switch point from non-migration to migration. Also: fish life history evolution, regulation (physiology). Eric: "Now, I orientate my work towards understanding how selection for smaller carnivores from global changes (harvesting, warming, habitat fragmentation) affects food-web structure and ecosystem function, and how ecosystem changes alter selective pressures on carnivore body sizes (the eco-evolutionary feedback loop)." See also PNAS Daufresnes 2009.

Stéphane Legendre
Population dynamics: developed the ULM software.
Adaptive dynamics; idem ZEN software.
Current research concerns graph theory applied to food webs: (to what extend) can we simplify complex food webs?

Andres Lopez-Sepulcre
Works on fish, gyppies, evolution, streams, subtropics.
Why rapid evolution? Size-dependent life history.
Phyto -> Invertebrates -> Fish. Treatments: yes/no predation. High/low light. Observe: community change in Phyto (bethic diatoms). Size-distribution change in invertebrates.

Regis Ferriere
Develop math tools for eco-evo analysis, time series, Bayesian approach to fit models. (NB, there is a possible link in this respect between the work of Regis, Andres and that of Vincent le Bourlot in ANR Evorange…).
Regis presents us his work on the metabolic theory of ecology. Collaboration with Enquist (coffee breaks in Arizona). Global biodiversity patterns. Allen et al (2002), Allen et al (2006), Hawkins et al (2007). Tittensor (2010).. Distill relation between temperature and biodiversity. Temperature influences generation time; metabolism; ecological interactions; mutation rate; env. res (Regis what does "env. res." mean in this context?). Influences both niche diversity & speciation rate. Relation to phytoplankton diversity? Regis proposes an approach in which temperature influences metabolism and body size (with interaction between these influences); in turn, metabolism and body size influence mutation rate, ecological interactions, and env. res. Incorporated these effects in a self-assembling and evolving, size-structured food webs (à la Nicolas Loeuille). Use to predict relation between temperature & diversity.
Regis would like to apply this kind of analysis to marine systems (no yet done) in the context of the Phytback project.

Francesco D'Ovidio
Biophysical interactions in the ocean. Meso-scale 10s-100s km. Vortices structuting biology. On time scales of weeks-months. Resonance, ocean turbulence – phytoplankton. Coupling physics & biology, biogeochemical cycles. Observational. Multi satellite data. Vortex -> niche. Works in Phytback with Silvia. LOCEAN, Tango framework, Marina Levy. GCM. Data: predators (sea elephants) carrying sensors: indicators for food etc. Vortex/filaments: "megacosm", observe phytoplankton dynamics.
Applied for recruiting a PhD: top-down control of biogeochemical cycles, zooplankton. At the Alfred Wegener Institute. September next year if accepted.

Silvia
1. Mechanisms/mechanistic evolution of cooperation. PhD project Thomas Garcia. Group size; game theory; amoeba Dictyostelium; phytoplankton? Infochemicals; siderophores: fix iron; public goods games).
2. Evolution of phytoplankton cell size, with A Provenzale. Jiang et al 2005 revisited. Add turbulence, influences sinking rate. More turbulence: less fitness differences small/high sinking rate. Still water: large cells sink faster, low fitness. Shape: influences exponent in Stokes law (?)
3. Plankton biogeography, advection simulation, mesoscale. Simulate ecosystems. Satellite data -> diversity (hot spots). Relate to TARA, MITgcm.

(TASK 3: Francesco: satellite -> compare TARA, MITgcm)

Mick
- Arrived at MIT in 1992. Main themes of his work: carbon cycle, ocean circulation, biogeochemical cycles. Since 2000: modelling of "self assembling" communities/ecosystems, nitro fixers. Longhurst biogeographical provinces (based on zooplankton); large-scale organisation of biogeochemical cycles, i.e. "emergent provinces"? Cross-ocean transects of phytoplankton and zooplankton abundance/biodiversity (closer to coast, more zooplankton).
- Size-structured food web. Bigger size classes in more productive systems
- Pigments
- Models of cell physiology. Metabolic network (i) Dynamics Energy Budget (DEB) approach; bottom up approach
- Whay Phytback: interested in having more ecology, adaptive dynamics, food web, cell biology in his work.

Chris
Diatoms, genomes. *Thalassiosira pseudonana, Phaeodactylum tricornutum*. You need about 10,000 genes to make a diatom.

(I) Diatom evolution? Yeast+green alga+red alga. 3X nuclear genomes. 3x mitochondrial. 2x chloroplast. + genes from bacteria. Diatoms have metabolic properties of both plants and animals. Both fatty acid oxidation (animal) and sugar (plant). Urea cycle (animal) for mobilising nitrogen.
Iron limiting conditions: P. tricornutum: gene expression; analysis of metabolome.

(II) blooms. Communication between individuals? Do cells "decide" to grow exponentially? To decline suicidally? Signal of cell death; relation to immunity? (&memory through cell division) The same molecule also decreases the zooplankton fecundity (anti-predator behaviour?). Evolution of suicide?

(II) TARA. 1. Understand spatio-temporal plankton network organisation (biology). 2 …in physico-chemical context.

Boris
Did master (M2) project with Chris & David, implementing adaptive dynamics of phytoplankton in MITgcm. Has now started PhD project with same supervisors. Will continue master's work & work on modelling & experiments with *P. tricornutum*

Leila
Performing experiments, molecular biology with diatoms, in Chris' lab. Expertise in genomics, metabolomics, epigenetics, cell biology, lab work.

David.
Main experience: modelling (physiologically structured population models, adaptive dynamic). Main systems: freshwater fish populations (size-dependent competition, predation, cannibalism), evolution of resource use (size dependent or not), adaptive dynamics with simple

genetics and stochasticity, evolution in dynamic landscapes (with Robin Aguilee & Amaury Lambert). Recent projects: size-structured pop dynamics (with JF le Galliard, Manuela Gonzalez, Jan Ohlberger, Eric Edeline, Vincent Le Bourlot, Thomas Tully), phytoplankton modelling (with phytback).

Presentation & discussion of the different Tasks

(see also PDFs of the presentations).

Task 1. Project coordination (David)
David coordinates the project in terms of project-wide meetings such as this one, the reports (6 months, mid-term, and final). He will go to a meeting at the ANR in Paris to be briefed on how to do this.

Task 2. Generic modelling (David)
In addition to the slides, note the following. An important part of this task is the development of relevant and operational fitness measures in complex models (1d, 3d, including (or not) complex population structure). Populations can be structured spatially, and/or physiologically in terms of cell size, cell shape, nutrient quota, colony/solitary. Study a range of models (complexities). Specific objectives to model: epigenetics, colony formation. An interest in colony formation/dynamics/evolution emerged during this meeting. This subject was not explicitly mentioned in the project but could be an interesting twist to the idea to study the evolution of "cell size and shape". Also, there are interesting cross-Task and cross-Partner links on this subject, since this is quite well studied in freshwater systems (Gérard) while the marine system seems to have a strong interest (Mick, Francesco, Chris). Concerning epigenetics, remarks were made: Chris finds interesting the idea that epigenetics may affect a large proportion of the population simultaneously, which makes it very different from the genetic (mutation) context, in particular the adaptive dynamics view of the latter. Also, this aspect make (demographic) stochasticity less important (large numbers). Regis: this will speed up (evolutionary) dynamics, avoid thresholds. Chris: epigenetic traits are typically quantitative traits. What about the standing epigenetic variation? What is known? It appears Troy Day works on epigenetics; we propose to invite him to Paris.

A discussion on the recruitment of a postdoc (there are almost 3 years for a postdoc). Two suggestions; (i) Silvia and Francesco know a geophysicist (Italian) who is interested in ecology. Is skilled in computing. (ii) a postdoc currently with Mick at MIT, Ben Ward from the UK, may be interested, but later on (he has another 18 months at MIT).

Task 3. Marine system. Chris. See also PDF file: "xxx.pdf"
<u>Lab work</u>
One plan is to use *P. tricornutum*, in particular in the PhD project of Boris. Should we use this species?

- Not a good model species?
    - It is a very local species
    - morphology: weird, abnormal (the polymorphism of morphotypes is not normal
- A good model species?
    - Physiology well studied
    - Transitions between morphotypes quite well known
    - One could measure: nutrient uptake; storage capacity (for different types)
    - All forms make chains / aggregates (oval type)
    - Different sinking rate per type
- Photoreceptor *Phy* red light

    - Knock out Phy → they form chains
    - Measure population size?
- Ten different ecotypes from around the world

Experimental evolution
measure genetic / epigenetic change
- 1000 generations "good" conditions → measure standing variation
- 1000 generations under stress, then remove stress

Eric: start from population (sampled from ocean). From initial conditions, impose stress 1, then measure standing var; then impose stress 2. Evolution of adaptability/evolvability?
Mick: thought about this. Can do chemostat experiments.
Silvia: fluctuating environments

Task 3. Freshwater system. Eric, Gérard.
So far: no focus on phytoplankton in the projects of the Bioemco team.

- Main question: consequences of the complexity of food web? Contest the linear vision of food chains. They found the contrary: often complex webs behave like food chains. E.g. trophic cascades.
- Mesocosm experiments. (2011-2014). PULSE project. Location: Foljuif CEREEP; and Creteil lake. Anthropic experiments: affect top species (size structured food web); allochtonous/autochtonous organic matter; nutrient loading; water turbulence? (Florence Hulot).
    - Analyse: fish; zooplankton community (taxon; size; demography; "plasticity"); phytoplankton (main phyto groups (BBE probe); limiting factors; taxon composition; size structure; morphology cf. Chris)
    - Modelling: Elise Thebault; Sebastien Barot; (food web, nutrient cycling; but no adaptation → hence complementary with Phytback project; collaboration?)
    - Stoichiometry: with/without fish→ change in N:P ratio
    - Topological approach: go from 0-1 food web to weighted matrices (Stéphane)
    - "Adaptation cascades"
    - Ceratium hirundinella. Dino. 3 horns if with cladoreans. 1-2 horns if without.
    - Scenedesmus: lab model system. Predator-prey system. Possible to use in Phytback project? Collaboration with Chris' lab? Relation between body size and colony formation.
        - N limited. Colony "coenobium". Low photosynthesis; low energy requirements(???); low RNA production
        - P limited. Thick walled cells, small colonies, high photosynthesis & energy, carbohydrates accumulation; decrease DNA/RNA, delayed cell division

Eric:

- the current Foljuif experiment: We manipulate presence/absence of zooplanktivorous fish (top-down effects on algae) with/without allochtonous inputs (bottom-up effects on algae), and record algal and zooplankton community composition, as well as water chemistry (Gerard, please correct me if I am wrong).

- The modelling should *direct* the experiments. What is achievable model-wise? Feed to experiments on the complementarity between the approaches of Elisa Thebault, Sebastien Barot and yours.

- You might mention that I have applied for an ANR jeune chercheur (acronym TOPPLE), in which one of the 3 tasks (led by Elisa) is to model the effects on food web dynamics of top predator body-size evolution using quantitative genetics (including eco-evolutionary feedback

loop(s)). Phytback is thus leading the way for developing the study of eco-evolutionary dynamics at ENS, and the integration of eco-evolutionary dynamics at the ecosystem scale (complementarity, synergies, emulation... etc). Actually, I think it might be interesting to include Elisa in the Phytback diffusion list (ethebaul@biologie.ens.fr).