Working document

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General idea: How can the terrestrial plant literature on seed bank be applied to phytoplankton coexistence?

Introduction

[[[I think we should have an even more general paragraph before the next one, that is already too technical/precise, maybe?]]]

The high biodiversity of plant communities has long been a subject of both experimental and theoretical ecologists. Analyses of coexistence in terrestrial plant communities often take into account several life stages [refs]. Considering at least two stages, seeds/juveniles and adults, different models have uncovered mechanisms that might explain long-term coexistence. Bet-hedging is a long-term strategy relying on the creation of seeds which can remain dormant for a long period of time (over a year, often much longer). Dormant seeds can tolerate harsher years during which adults cannot maintain, but they also reduce part of the population that could germinate from one year to another (in case of an annual plant). The storage effect is another mechanism that unfolds from seed bank formation (Chesson & Huntlu 1989, Ellner 2016?): this mechanism requires a negative correlation between the effect of the environment and the effect of competition. In good enviromental conditions, competition from other individuals is stronger. Finally, models and experiments suggest that adults can have a negative effect on seeding survival, through the Janzen-Connell effect [refs].

Even though different coexistence mechanisms have been unveiled through the use of several life stages and a focus on the youngest stage (seeds) for terrestrial plants, aquatic plants, and more specifically phytoplanktonic algae, have not been modeled with the same precision. Although theoreticians have proposed for a long time that the blooms may initiate after the resuspension and germination of seeds (Gran 1912, Marcus and Boero 1998), it is unusal to see an explicit model of such process. The classical view behind phytoplankton dynamics is that bloom formation is mostly seasonal, due to the variation in light and temperature, assuming that there are always enough cells in the environment to duplicate. However, a recent review suggests that there might be more complexity behind phytoplanktonic seeds/cysts [Ellegaard and Ribeiro, 2018]. Neglecting explicit modeling of this life stage can modify the understanding we have of the dynamics of the populations [Nguyen et al., 2019].

Phytoplankton communities in coastal environments may benefit from seed banks even more than the oceanic communities, as the distance to the bottom is lower. Similarly to the seed bank approach, Smayda [2002] has proposed the term "pelagic seed bank" to characterize the contribution of the ocean to coastal communities. This has been noticed for dinoflagellate especially [[ref Dinophysis, check what we have on diatoms]]. We can wonder, however, to which extent the seed banks can contribute to the biodiversity in the ocean, especially in the long term. Indeed, spores are able to germinate again after tens of years [McQuoid et al., 2002, Ellegaard and Ribeiro, 2018] or even thousands of years [Sanyal et al., 2018] of dormancy, which can play a huge role on biodiversity in both oceanic and coastal environments.

Here we build on the work by Shoemaker and Melbourne [2016], Wisnoski et al. [2019], and previous findings inPicoche and Barraquand [2019a,b], to examine the effect on coexistence and feedbacks from the different compartments (ocean, coastal water column and bottom).

Model

$$N_{t+h,i,c/o} = \frac{e^{r_i(T)} N_{t,i,c/o}}{1 + \sum_j \alpha_{ij,c/o} N_{t,j,c/o}}$$

$$N_{t+h,i,b} = N_{t,i,b}(1 - m_i)$$

Param	Name	Value
$r_i(\mathrm{T})$	growth rate of species i	from Picoche and Barraquand [2019a]
T	temperature	
$\alpha_{ij,c/o}$	interaction strength of species j on i	
m_i	seed mortality of species i	
s_i	sinking rate of species i	
e	exchange rate between ocean and coast	
γ_i	germination + resuspension rate of species i	

Table 1: Definition of main parameters in our model

$$N_{t+1,i,c} = N_{t+h,i,c}(1 - s_i - e) + \gamma_i N_{t+h,i,b} + e N_{t+h,i,o}$$
$$N_{t+1,i,o} = N_{t+h,i,o}(1 - e) + e N_{t+h,i,c}$$
$$N_{t+1,i,b} = N_{t+h,i,b}(1 - \gamma_i) + s_i N_{t+h,i,c}$$

For the interactions, we can have $\alpha_{ij,c} << \alpha_{ij,o}$ and $\alpha_{ii} \sim 10|\bar{\alpha}_{ij}|$.

Regarding the distribution of the coefficients itself, we can use what we had in Picoche and Barraquand [2019b] (maybe check that it can be matched by what was used for the 20-species example in the GC paper?)

Results

References

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