Stochastic Dynamics in Ecology

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Summary

Ecological systems are subject to random phenomena. In the Trondheim collaboration, we computed the effects of harvesting and competition in the population synchrony scale. These results provide new tools for a **better management of harvesting and conservation**. This collaboration continues now in the framework of the SUSTAIN Norwegian project for the sustainable management of terrestrial, freshwater, and marine ecosystems. In the Bergen collaboration, we have address the size and nutrient scaling of phytoplankton, and their relations to their internal traits. These results describe phytoplankton composition, and will be relevant to **understand the dynamics of fisheries resources**. Also in this collaboration we have studied the parasite infection risk of salmon at different situations. These results will help **reduce the parasite infection risk of farm and wild salmon**. This second collaboration is now in search for new funding to continue research.

Population synchrony scale

Populations fluctuations are synchronized over a certain distance l. This correlation scale, in many cases, is given by the correlation scale of the environmental fluctuations l_e (Moran effect [1]), and it is increased in the presence of migration [2]

$$l^2 = l_e^2 + \frac{m l_m^2}{r}$$

Thus, the population synchrony scale l increases when the growth r is smaller, and when migration is stronger (due to a greater fraction of population involved in migration m, or to longer migration distances l_m).

Effect of the harvesting

We show in Ref. [3] that constantly **harvesting** a fraction β of a species **increases** its **population synchrony** scale to

$$l^2 = l_e^2 + \frac{m l_m^2}{r-\beta}$$

Effects of competition

Competition generally increases the population synchrony scale of on species, whereas it decreases it for the other species. Thus, in general, **competition enhances differences in population synchrony scales** [3].

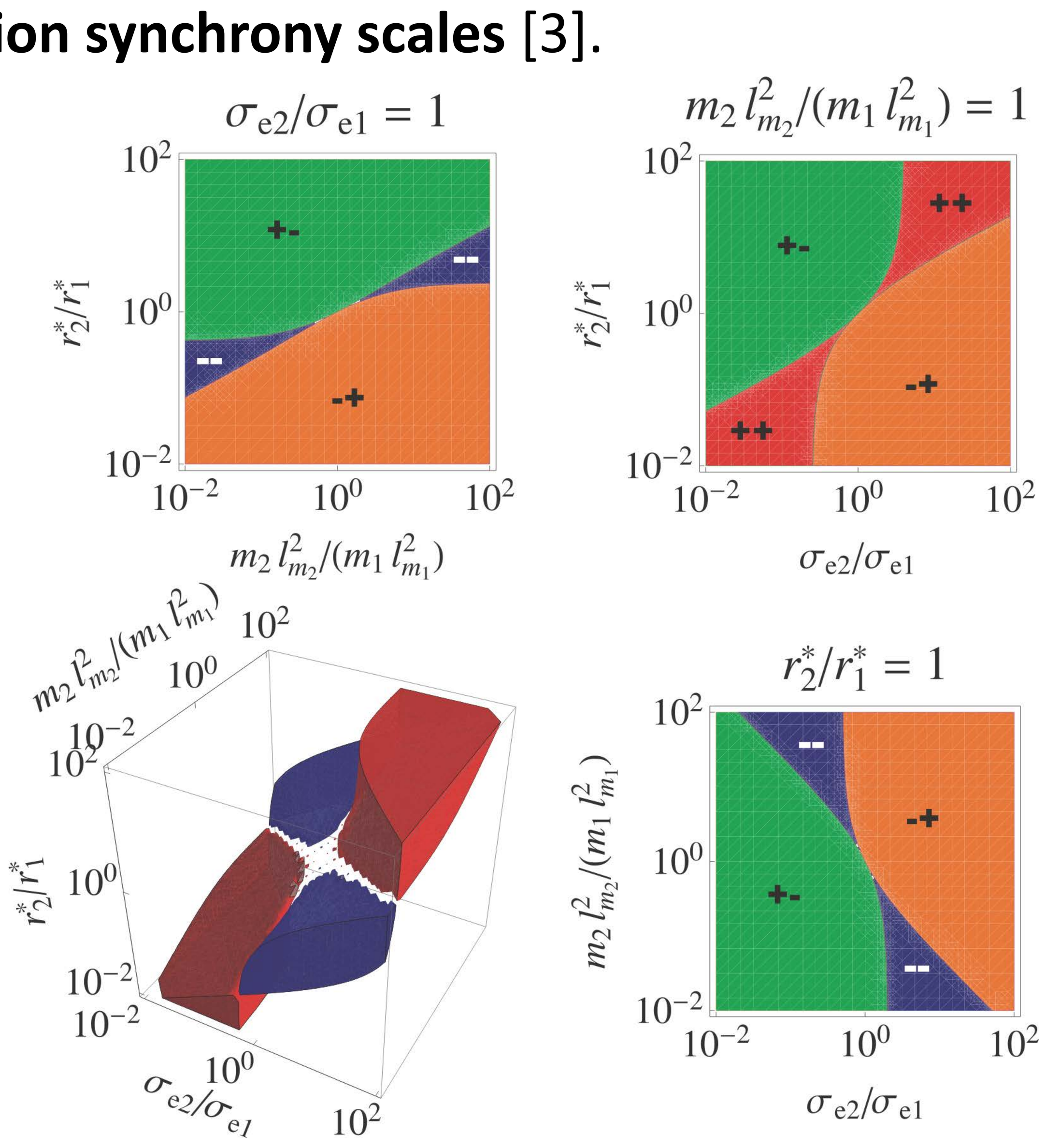

Fig. 1: Signs of the change of synchrony scale as a function of the two competing species parameters (σ_e is the amplitude of the environmental noise)

Implications for ecosystem management

Larger synchrony scale implies less independent population regions in space, and **higher risk that local extinctions become global extinctions.**

Phytoplankton scaling

We obtained the following relation for the phytoplankton size as a function of the nutrient concentration

$$r(\mu\mathrm{m}) = 0.036\, S^{\,0.84} (\text{molecules } \mu\mathrm{m}^{-3}).$$

We also expect from uptake data that the number of porters (entrance points of nutrients) scales with size as

$$n = 338\, r^{1.56} (\mu\mathrm{m}),$$

and the handling time inverted by a porter with each nutrient as

$$h\,(\mathrm{r}) = 1.90 \times 10^{-3}\, r^{-0.90} (\mu\mathrm{m}).$$

(See Ref. [4], where we used the model previously derived in Ref. [5])

Cost model

We shown that an effective porter cost of

$$V_{\text{cost}}(\text{molecules s}^{-1}) = 1.81\, n^{1.64},$$

in the uptake rate, implies the previous scaling of the number of porters with size.

Implications for fisheries resources

Phytoplankton is a key source of nutrients for the marine food chain, and fisheries are mainly located in phytoplankton rich areas. Our results provide tools for a **deeper understanding of phytoplankton composition and dynamics, and their implications for fisheries**.

Salmon parasite model

We shown that there is an optimal salmon speed which minimizes the parasite infection risk [5].

Implications for salmon management

This information provides clues for optimal situations of salmon farms in the appropriate fjord currents to reduce salmon parasite infection.

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References

1. N. J. Gotelli, A primer of Ecology, Sinauer Associates; 4th edition (2008).
2. R. Lande, S. Engen, B.-E. Saether, Stochastic Population Dynamics in Ecology and Conservation, Oxford University Press (2003).
3. J. Jarillo, B.-E. Saether, S. Engen, F. J. Cao, *Effects of harvesting and strength of competition on spatial scales of population fluctuations of two competing species*. Submitted (2016).
4. E. Beltrán-Heredia, D. Aksnes, F. J. Cao, *Optimal nutrient uptake and phytoplankton cell size scaling with nutrient concentration*. Submitted (2016).
5. D. L. Aksnes, F. J. Cao, *Inherent and apparent traits in microbial nutrient uptake*. Mar. Ecol. Prog. Ser. 440: 41–51 (2011).
6. F. J. Cao, O. Fiksen, *Infection rate in active parasites: the salmon case*. In preparation (2016).

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