

## Wind drives microbial eukaryote communities in a temperate closed lagoon

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Table S1: 18S rRNA gene identity of the abundant ribotypes listed in Table 2 (main text). The reads are identified to the closest species match following a BLASTn search. Average percent of similarity of reads to the species, and functional category (Cat): Dinoflagellates (Dino); heterotrophic nanoflagellates (HNF); mixotrophic nanoflagellates (MNF), which are referred to as Nanoeuks in the main text; and photosynthetic picoplankton (PPP), which are referred to as Picoeuks in the main text. The Picozoa were the only heterotrophic pico flagellate (HPF) and the uncultivated alveolates that are classified as Syndinales groups were considered parasites (Para). The size and functional role of the *Braarudosphaera*-like OTU is uncertain.

Genera	Accession number	Similarity	Cat
<i>Gyrodinium helveticum</i> clone LM083	FJ024299.1	99.3%	Dino
<i>Karenia mikimotoi</i>	FR865627.1	100%	Dino
<i>Scrippsiella hangoei</i> strain SHTV6	EF417316.1	98.4%	Dino
<i>Katablepharis</i> sp. POVA-MDc39	JN934894.1	99.0%	HNF
Picozoa MS609-66	JN934893.1	98.9%	HPF
<i>Chrysochromulina simplex</i> UIO047	AM491021.2	99.0%	MNF
<i>Falcomonas daucoides</i>	AF143943.1	98.8%	MNF
<i>Pyramimonas</i> sp. RCC 2500	JN934689.1	98.3%	MNF
Uncultured MALV group I	KC488461.1	99.5%	Para
<i>Aureococcus anophagefferens</i> Q1-8	JQ420084.1	99.5%	PPP
<i>Bathycoccus prasinos</i>	FO082268.1	99.8%	PPP
<i>Micromonas pusilla</i>	AY955010.1	99.7%	PPP
<i>Nannochloris</i> sp. KMMCC C-275	GQ122381.1	99.9%	PPP
<i>Ostreococcus lucimarinus</i> CCE9901	CP000592.1	99.7%	PPP
<i>Picochlorum</i> sp. HM1	FR854360.1	99.5%	PPP
<i>Braarudosphaera bigelowii</i> isolate: Yatushiro-1	AB478414.1	96.5%	PPP ?

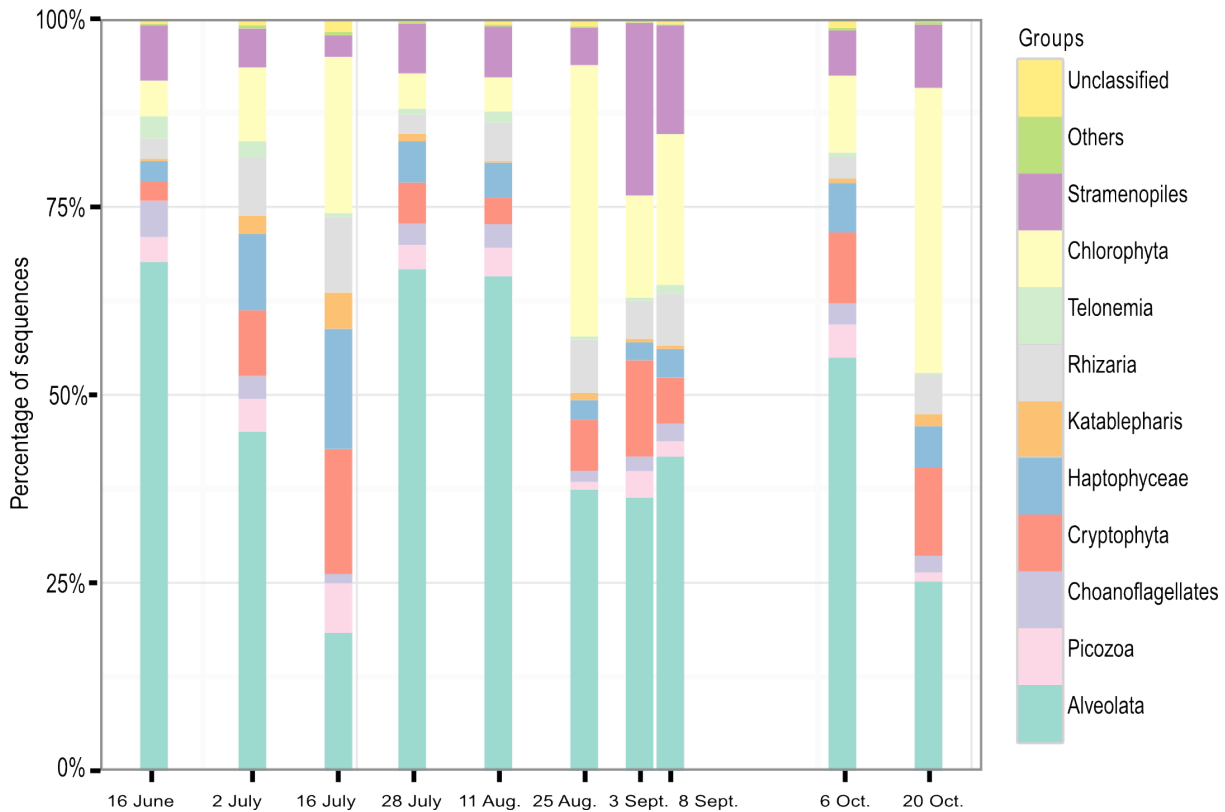


Figure S1: Major microbial eukaryotic groups found in the Havre-aux-Maisons Lagoon from June through October 2009. Percentage of sequences of the total remaining after removal of bad quality sequences, metazoans, fungi, terrestrial plants and chimeras.

### Description of the enemy-victim model

We used a population-dynamical, deterministic model, to simulate the variation in population size of one species of victims and one species of enemies. Relative to the biological system studied, enemies are assumed to be dinoflagellates, and victims to be phototrophs. The instantaneous rate of change *per capita* in the population of enemies ( $E$ ) and victims ( $V$ ) is given by

$$\begin{aligned} 1/V \, dV/dt &= r_V - q_V \times V - \alpha \times E \\ 1/E \, dE/dt &= r_E - q_E \times E + \alpha\beta \times V \end{aligned}$$

In the model, the victim and the enemy grow at rate  $r_V$  and  $r_E$  respectively, and compete at rates  $q_V$  and  $q_E$ , respectively. Victims are consumed by enemies at a rate  $\alpha$ , and converted into enemy biomass at a rate  $\beta$ . This linear functional response was chosen to minimize the number of model parameters.

This formulation is close to the canonical Rosenzweig–MacArthur model of predator-prey dynamics, with the exception that enemies can grow in the absence of their victim. The growth rate of dinoflagellates is known to be lower than for of phytoplankton and all of the simulations were carried out with  $r_V \geq r_E$ , here respectively, 1 and 0.5.

In the absence of the enemy, victims reach the equilibrium density

$V^* = r_V / q_V$ . In the absence of the victim, enemies reach the equilibrium density

$E^* = r_E / q_E$ . As dinoflagellates, being typically larger cells, are expected to be less abundant than phytoplankton in nature, we choose conditions that ensure  $V^* \geq E^*$ , which is to say that  $q_E / q_V \geq r_E / r_V$ .

## 1-Two-species equilibrium

In the presence of both species, there is one non-trivial, two-species equilibrium. It results in:

$$V^* = (q_E r_V - \alpha r_E) / N$$

$$E^* = (q_V r_E + \alpha \beta r_V) / N$$

$$N = \alpha^2 \beta + q_E q_V$$

As  $\alpha, \beta$ , the competition rates and growth rates are all strictly positive for biologically realistic values,  $N$  is strictly positive, so both equilibrium densities are the same sign of their numerator. It follows that  $E^* > 0$  for all biologically realistic parameter values, and  $V^* > 0$  whenever

$q_E r_V > \alpha r_E$ . Accounting for the previous restrictions, the two-species equilibrium exists whenever  $\alpha < q_E \times (r_V / r_E)$ . Biologically speaking, enemies that have a high rate of victim consumption ( $\alpha$ ) will lead to the local extinction of the victim population.

## 2-Stability of the two-species equilibrium

The Jacobian matrix of this system evaluated near the two-species equilibrium is:

$$\mathbf{J} = \begin{array}{cc} -q_V V^* & -\alpha V^* \\ -\alpha \beta E^* & -q_E E^* \end{array}$$

The stability of this equilibrium can be assessed using the Routh-Hurwitz criteria, *i.e.* the equilibrium is locally stable if  $\det(\mathbf{J}) > 0$  and  $\text{Tr}(\mathbf{J}) < 0$ . This happens for  $\alpha < q_E \times (r_V / r_E)$ , meaning that whenever the two-species equilibrium exists, it is locally stable.

## 3-Oscillations

Empirical measurements of the system in nature revealed oscillatory dynamics, which were hypothesized to reflect stochasticity in nutrient availability for phytoplankton. To reproduce this effect, we used a C99 implementation of this model, in which we introduce variability in nutrient availability as a result of system perturbations. Assuming that nutrient input will increase the growth rate of the victim, we re-express the growth rate of the victim as:

$$r_v(t) = r_{v0} + \beta(\mu; \sigma)$$

where  $\beta(\mu; \sigma)$  is a value drawn at random from a beta distribution of parameters  $\mu$  and  $\sigma$ , and  $r_{v0}$  is the growth rate of phototrophic plankton in the absence of extraneous nutrients input.

## 4-Numerical experiment

Using the stochastic version of the model presented above, we conducted simulations using  $\mu = 0.0$  and  $\sigma$  in  $\{0.1; 1.1\}$ , corresponding to respectively, low and high impact of perturbations (<https://gist.github.com/tpoisot/7296981>). The results suggested that whereas low perturbations resulted in the analytically derived stable equilibrium, increasingly perturbed regimes produced dynamics mimicking those observed in systems with sustained oscillations (Supplementary Figure S2). We proposed the following ecological mechanism: rare, but strong, perturbations, project the phototrophic plankton population over its carrying capacity. This in turn increases the predatory component modeled as dinoflagellate growth rate ( $-\alpha \beta V$ ). As the perturbation is not sustained over time, both populations return to their carrying capacity. Thus, in any system that is disturbed by infrequent but strong perturbations that could contribute to nutrient input, such as wind acting to suspend sediments in the Havre-aux-Maisons lagoon, cyclic dynamics are likely to be observed. We note that the increased capacity of dinoflagellates to graze during quieter periods would amplify this effect, but this was not tested.

Literature Cited:

Rosenzweig ML, MacArthur RH (1963) Graphical representation and stability conditions of predator-prey interactions. *Am Nat* 97:209–223.

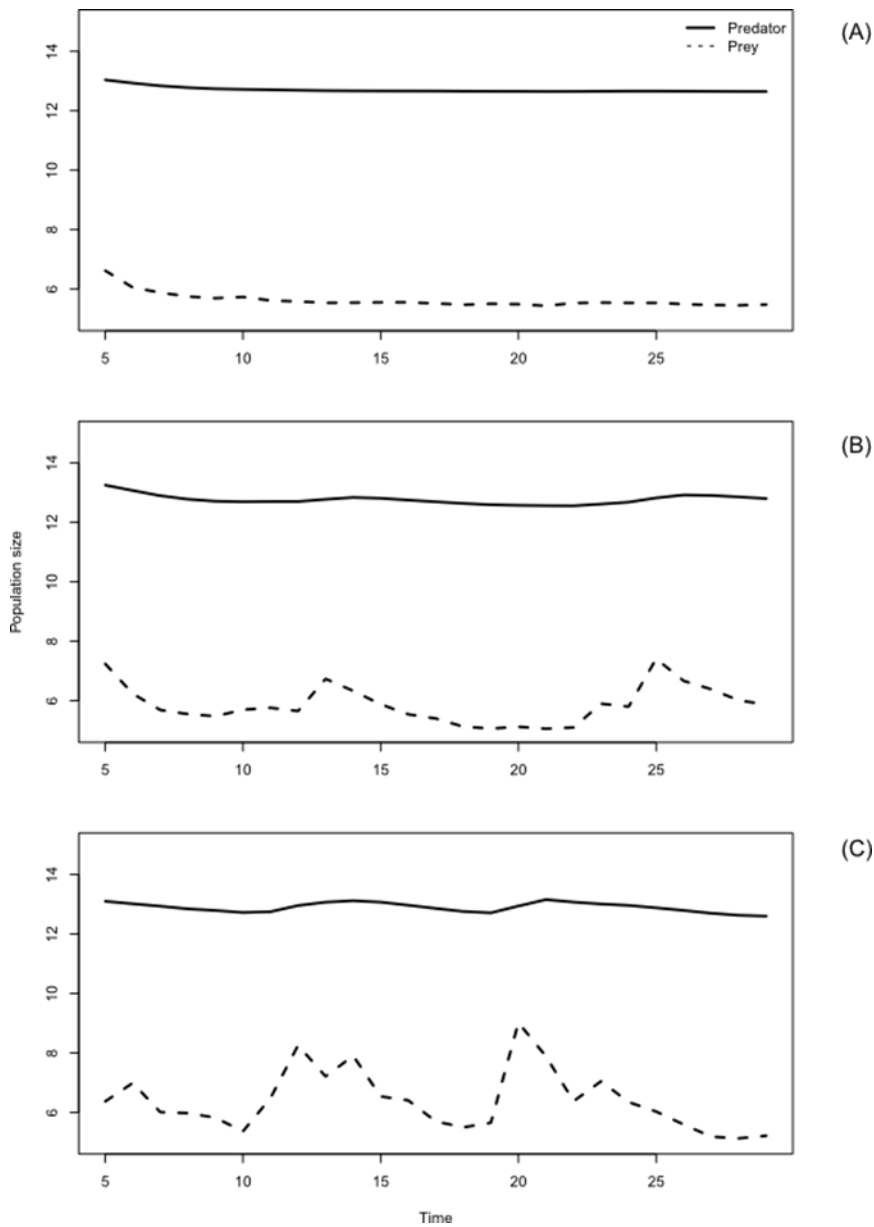


Figure S2: Enemy-victim model results for low (A), medium (B) and high (C) perturbations