Screening of the main light response features of Arctic diatoms over seasonal species succession

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Introduction

Dynamic interactions with snow and sea-ice, and extreme seasonal variations make solar energy an elusive and potentially harmful resource to harvest for diatom microalgae of the Arctic Ocean. The annual shift of environmental gradients, from early spring sea-ice covered to summer ice-free waters, triggers an explosive increase in biomass through the succession of many sympagic and planktonic species, which share diverse ecophysiological features. Climate change is inducing a decline in Arctic sea-ice extent and a longer open water season, which severely modifies Arctic diatoms' light environment[1] and could diminish their productivity and nutritive quality in the trophic chain[2]. It is therefore important to comprehend Arctic diatoms light response strategy with regards to their ecophysiological diversity if we are to improve our understanding of their seasonal succession and of primary and secondary production trends in the Arctic Ocean, under present and future light conditions.

Objectives

To define how the light response strategy of Arctic diatoms is influence by:

(1) The light environment of their different ecological niches and;

(2) Their ecophysiological diversity.

Materials and methods

Lab growth of 8 Arctic diatoms strains representative of their eco(physio)logical diversity over seasonal species succession.

(1) Determination of the growth rate at 6 irradiances: from light limiting to over-saturating.

(2) Analysis of photoprotection induction kinetics with short light stresses (NPQ and XC) under two growth irradiances: limiting and saturating.

(3) Response to a prolonged light stress (2h) followed by a relaxation period at low light (1h) (NPQ, XC, PSII repair cycle, LHCx proteins).

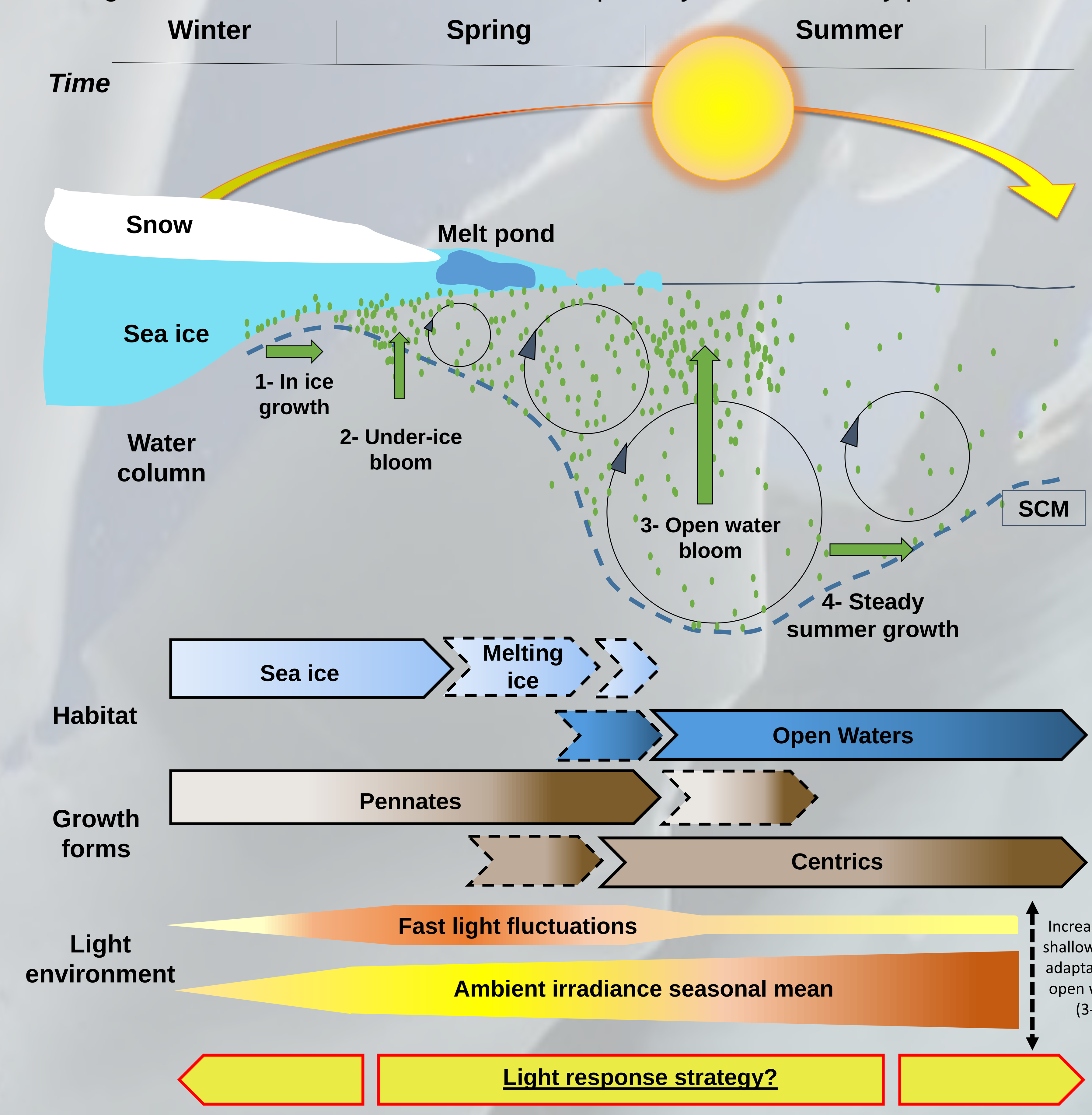

Figure 1: Schematic representation of the average Arctic diatom seasonal succession through the transition of 4 growth periods with distinct light environments. Ambient irradiance seasonal mean is controlled mainly by snow and ice thickness and structure, solar angle, photoperiod and depth adaptations, fast light fluctuations are mainly controlled by snow melting, ice break-up, vertical mixing and depth adaptations. The growth forms and respective eco(physio)logical features of the different species observed over succession are well known (Table 1) while the differences in their light response strategies remain poorly documented. Subsurface Chlorophyll Maximum (SCM) (Information from Wassmann and Reigstad 2011)[3]

Light response strategy features

K_E : Light saturation coefficient.

NPQ: Ability to dissipate light energy absorbed in excess (non-photochemical quenching)[5].

NPQ_S: Arctic diatoms' distinctive ability to sustain NPQ in prolonged dark periods[6].

XC: Kinetics of the xanthophyll pigments cycle which activate NPQ.

LHCx: Quantity of proteins that modulate the amplitude of NPQ according to environmental conditions[7].

Photosystem II (PSII) repair cycle which counters photinhibition[8].

Perspectives

This study will provide a first opportunity to link Arctic diatoms' high eco(physio)logical diversity and unique photophysiology. Data will eventually:

(1) Allow comparison with *in situ* measurements on sympagic and planktonic Arctic communities.

(2) Feed ecological modelling to improve our understanding of how diatom diversity could shift and impact the Arctic Ocean in the future.

Table 1: Arctic diatoms strains targeted by this study, their known eco(physio)logical features and life forms. Growth period numbers refer to Figure 1. In red are designated "model" species of their respective niche and represent the main genera in Arctic waters, experimentation 3 will only be performed on these species. Growth forms: pennate (P); centric (C). (Information from Poulin et al., 2011)[4]

Ecological niches		Life forms	Species	Ecophysiological features		
Growth period	Growth depth (m)			Growth forms	Biovolume (µm³)	Blooming ability
1	Ice	Sympagic	*Nitzschia frigida*	P	435	
1	Ice		*Attheya septentrionalis*	C	100	
1-2	No info	Sympagic and planktonic	*Fragilariopsis cylindrus*	P	105	X
1-2	No info		*Pauliella taeniata*	P	735	
2-3	30	Planktonic	*Thalassiosira gravida*	C	14 425	X
3	3		*Chaetoceros neogracilis*	C	95	
3	30		*Pseudo-nitzschia arctica*	P	450	
3-4	30		*Chaetoceros gellidus*	C	300	X

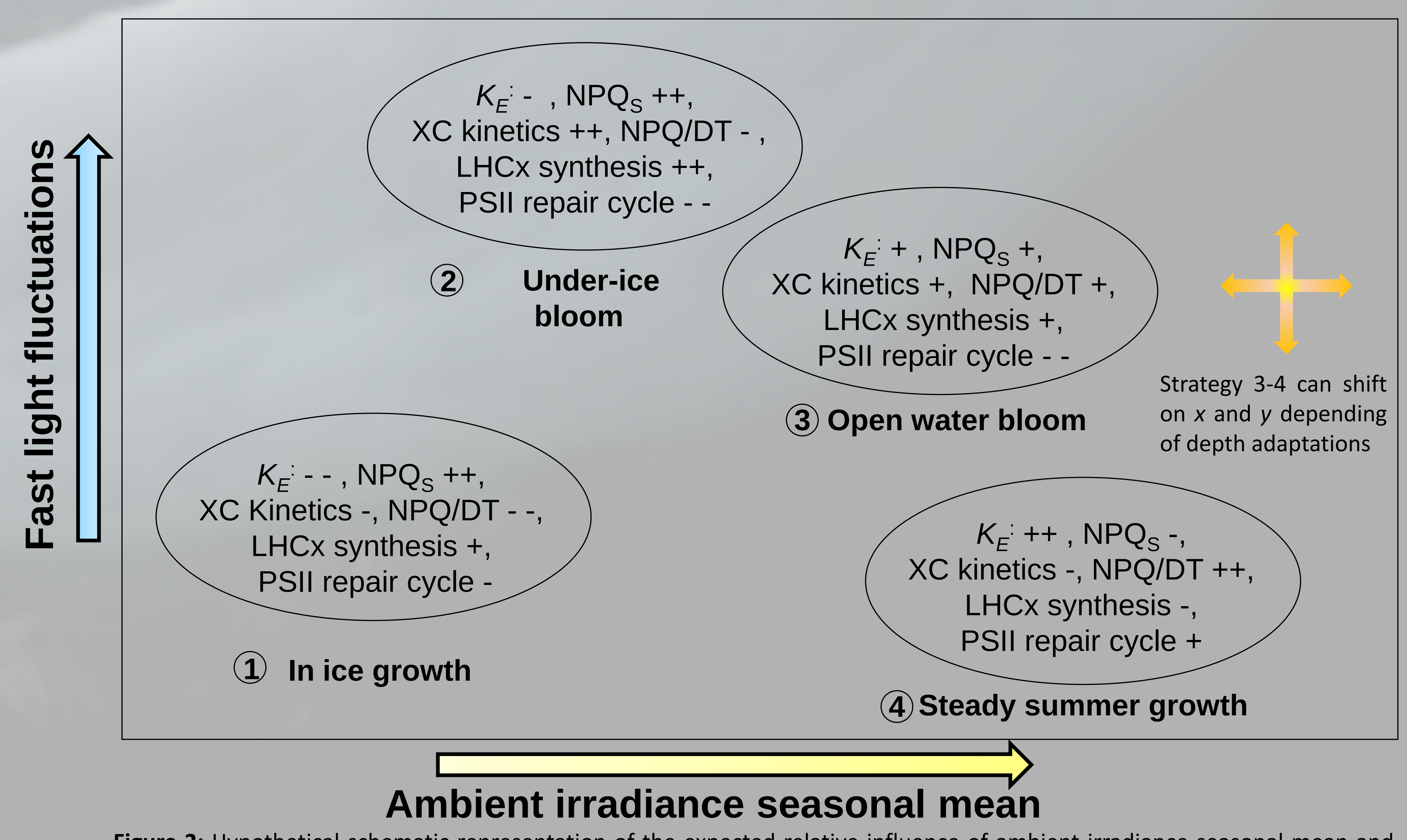

Figure 2: Hypothetical schematic representation of the expected relative influence of ambient irradiance seasonal mean and fast light fluctuations on the main features of the light response strategy of Arctic diatom species according to the light environment of their ecological niche (Table 2)

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