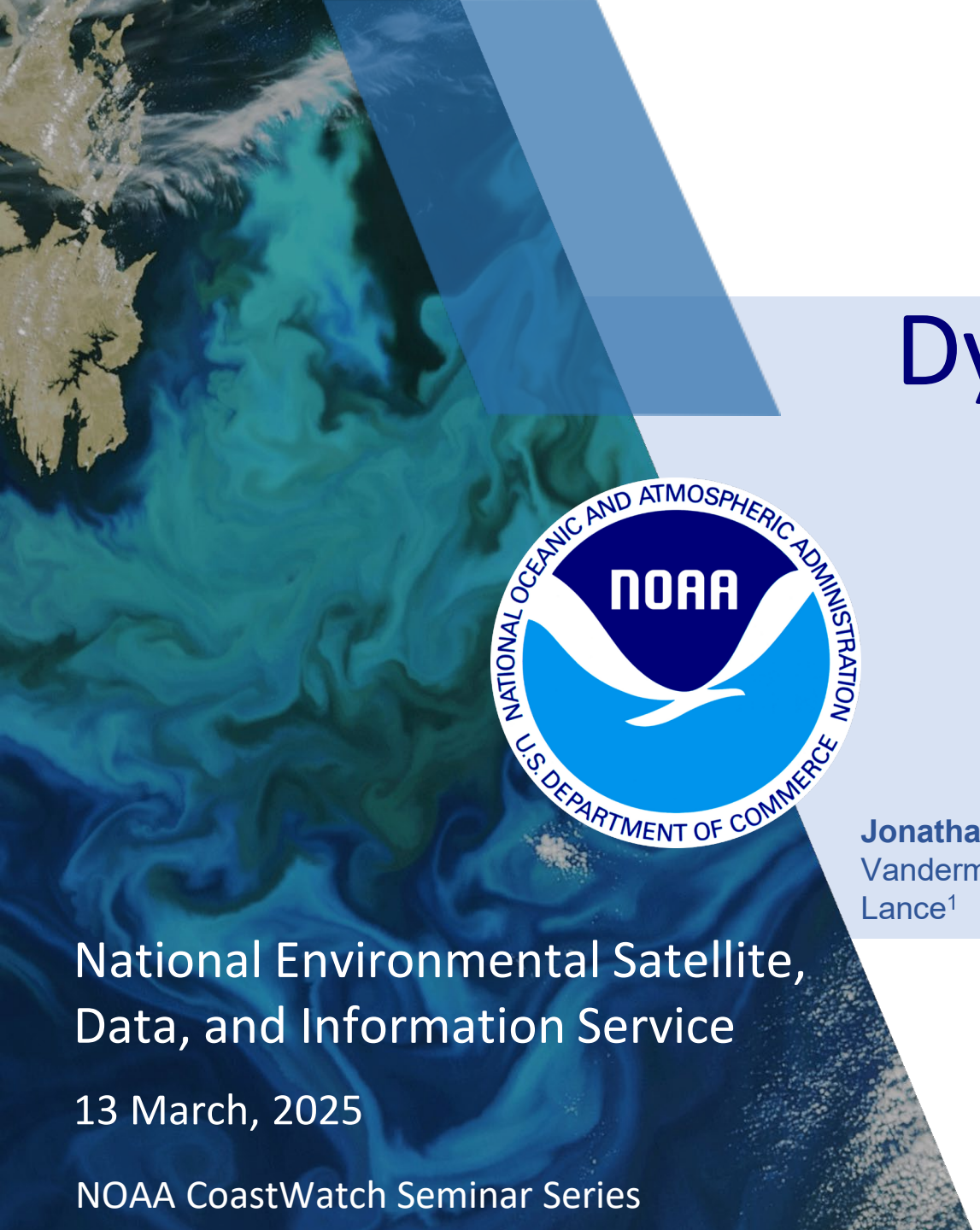


Dynamics in phytoplankton size class primary production in the East Bering Sea

Jonathan Sherman[1, 2], Dale H. Robinson[3], Cara Wilson[4], Ryan Vandermeulen[5], Kim Hyde[6], Jens M. Nielsen[7,8], and Veronica P. Lance[1]

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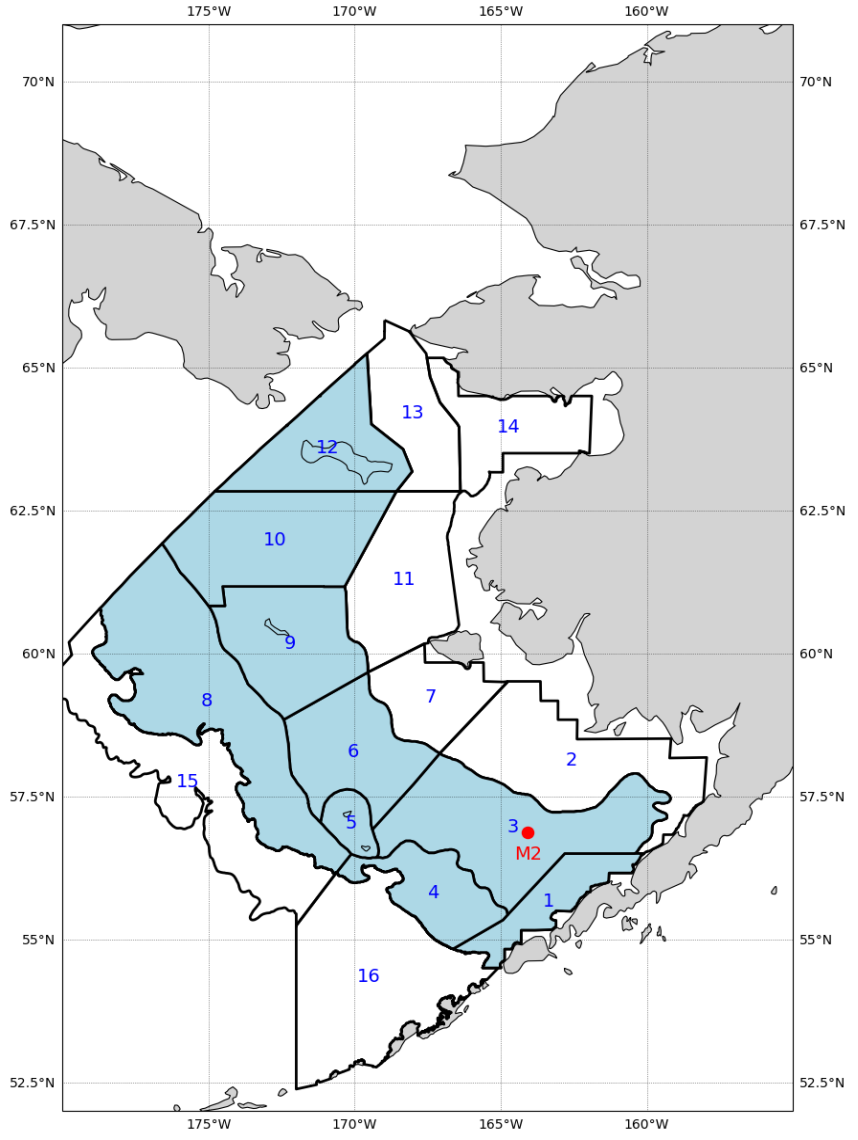
National Environmental Satellite, Data, and Information Service

13 March, 2025

NOAA CoastWatch Seminar Series

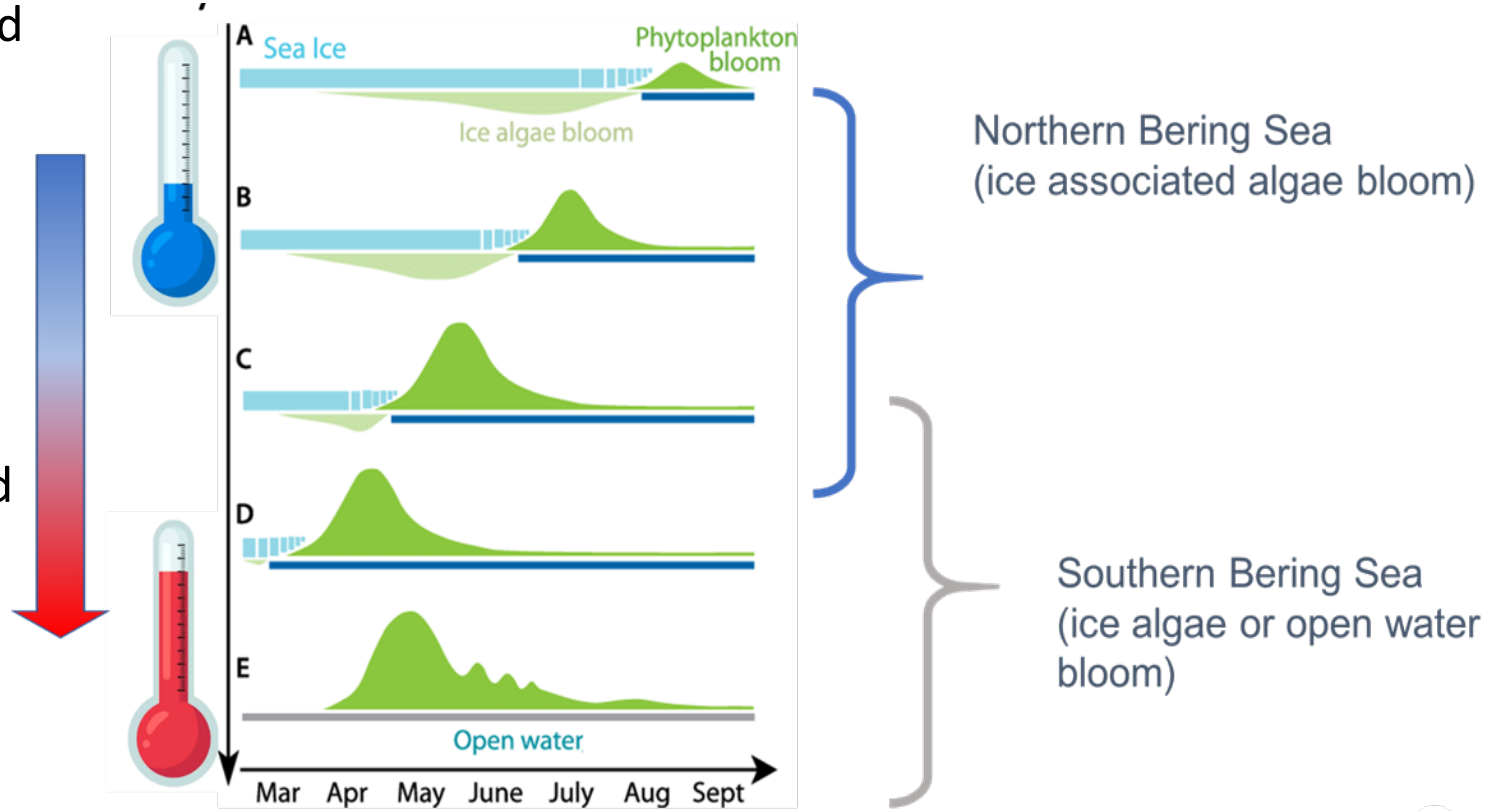
The East Bering Sea

- Extends ~500 km from the Alaska coast to the continental shelf break.
- Commonly divided into three regions, inner, middle and outer shelf (based on depth)
- A highly productive seasonal ecosystem
- Spring bloom dynamics directly impact benthic and pelagic consumers
- Large socioeconomic significance, represents ~50% of the U.S. commercial fisheries stocks harvest volume



The East Bering Sea

- Seasonally:
  - As ice retreats, spring bloom is dominated by large taxa (micorphytoplankton)
  - In summer, stratification increases, nutrients are depleted, production diminishes and community compositions shifts to smaller taxa (picophytoplankton primarily)
  - Smaller Fall bloom
  - Cycle is “interrupted” by storms and wind mixing, driving pulsed production
- The bloom timing and type highly dependent on ice extent and retreat



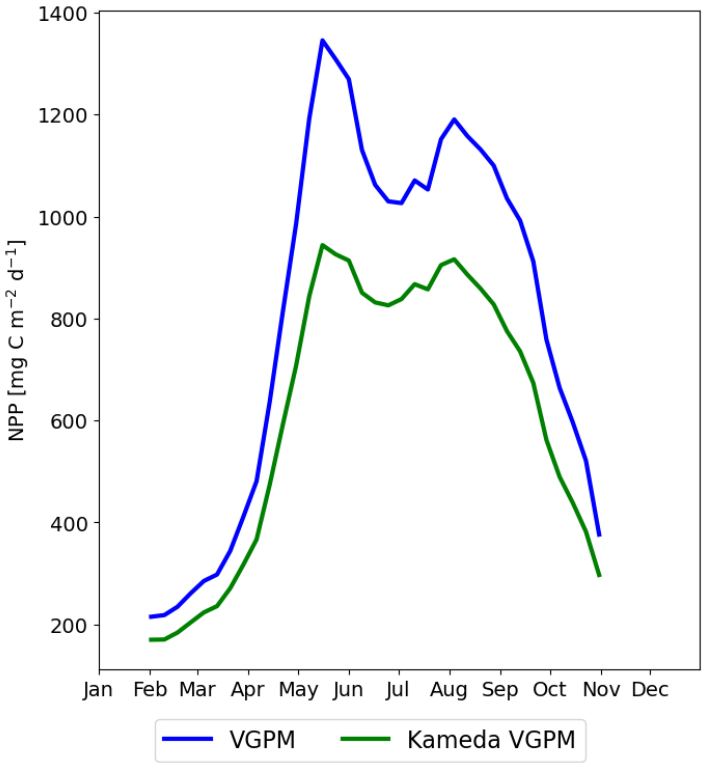
Wassmann & Reigstad 2011

Figure edited by Jens Nielsen

The East Bering Sea

- Limited ability to measure rates of Net Primary Productivity (NPP)
- Use of ocean color remote sensing retrieve NPP across the region is highly desirable. Added value for size-class(PSC) contributions
- Studies show commonly used models, like the Vertical Generalized Production Model (VGPM) are able to retrieve spring bloom timing and magnitude.
- However, seasonal cycle is misrepresented, with summertime production remaining high throughout out the season.
- Presumably due to the inherent dependency on SST in VGPM

2002-2023 climatology



Methods

OC-CCI v6
4km / 8Day 2002-2023 (limited to Feb-Oct)

NPP models-

- VGPM (Behrenfeld and Falkowski 1997)

$$NPP_{VGPM} = P_{opt}^{B} * \frac{PAR}{PAR + 4.1} * Z_{eu} * Chla * DL * 0.66125$$

P_{opt}^{B} from SST (Behrenfeld and Falkowski 1997) or from SST & Chla (Kameda et. al., 2005)

- PSC-AbPM (Zhongping Lee et al.)

$$NPP_{AbPM} = \phi * a_{ph} * PAR$$

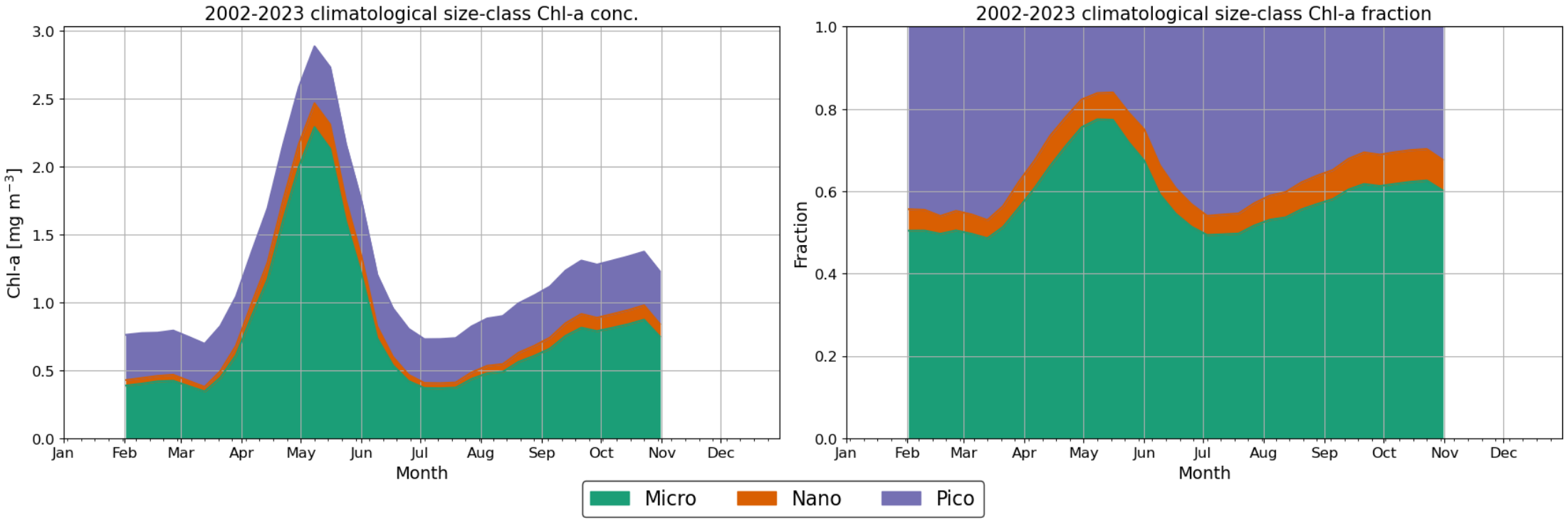
$$\phi = \phi_{\mathrm{m}} * \frac{\mathrm{k}_{\phi}}{\mathrm{k}_{\phi} + PAR(z)} * e^{-0.01 * PAR(z)}$$

ϕ- global 0.06 value

ϕ_{PSC}- Derived following a size class photo-physiological parametrization (Uitz et. al., 2008)

Chl-a_{PSC} – Derived following Brewin's 3 size class model, with East Bering Sea optimized coefficients

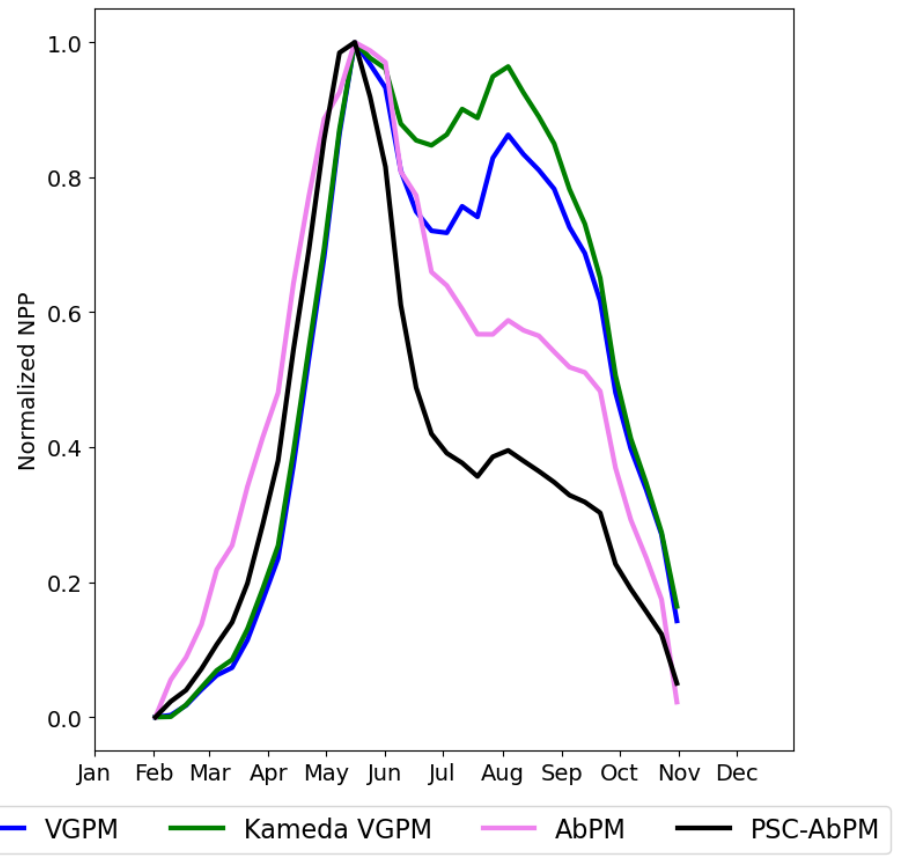
Results (Chl-a)



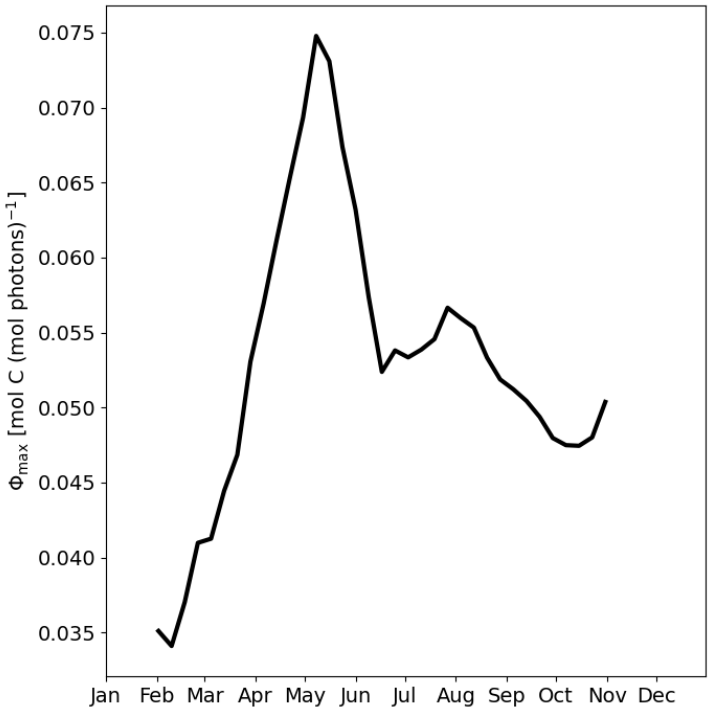
- Chl-a cycle as expected. With a Spring Bloom in April - May , and smaller Fall bloom around October.
- Size class in agreement with *in situ* observations reporting large cell compromising 70%-90% in the Spring, and <60% in the Summer.
- Contribution from Pico size class outweighs the Nano size class, in agreement with *in situ* data and “local” knowledge

Results (NPP)

2002-2023 climatology (Mid shelf)

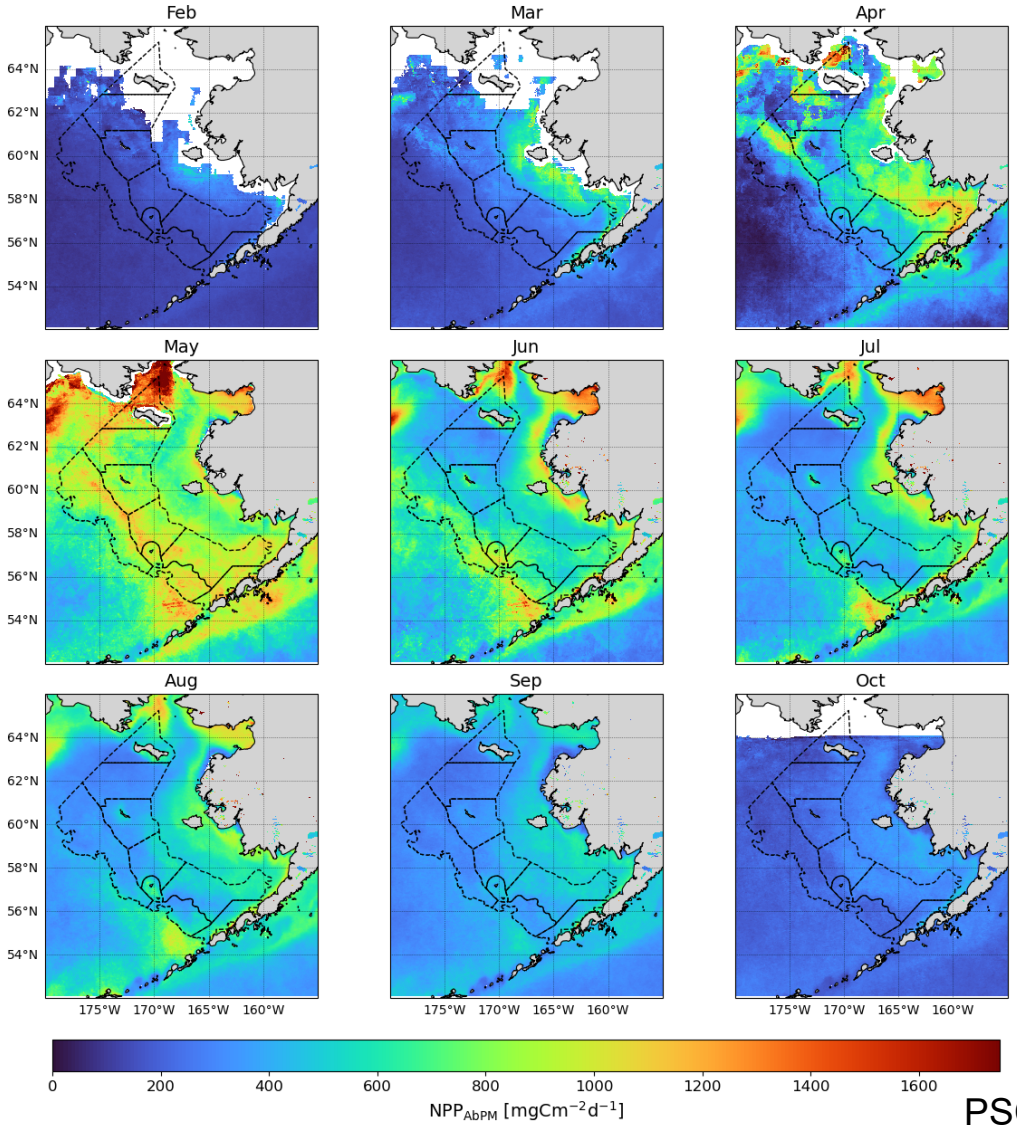


ϕ_{max}^{micro} climatology



NPP from AbPM and PSC-AbPM track VGPM bloom timing, but both show a rapid decline into the summer, and an additional Fall bloom. PSC-AbPM summer decline is more significant

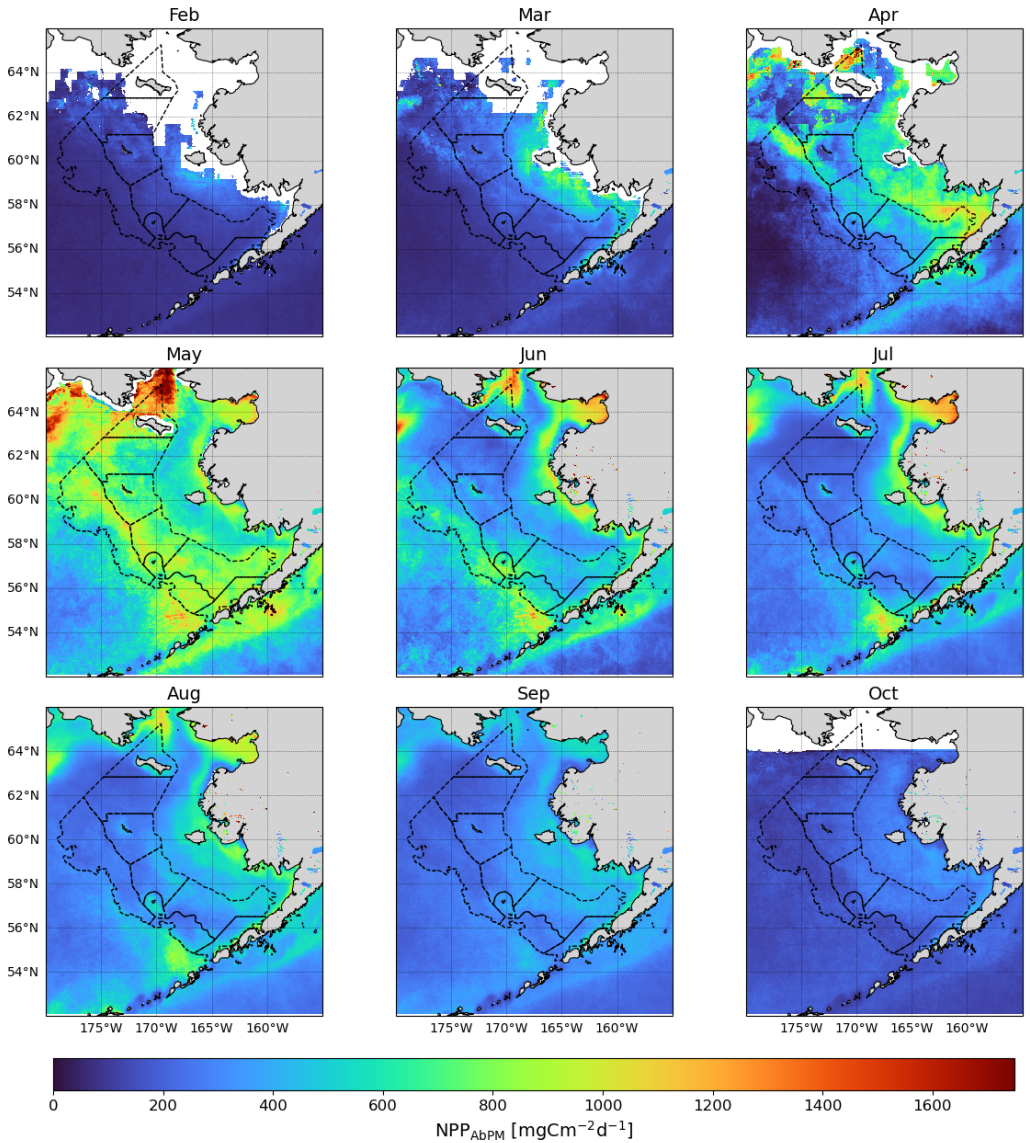
Results (NPP)



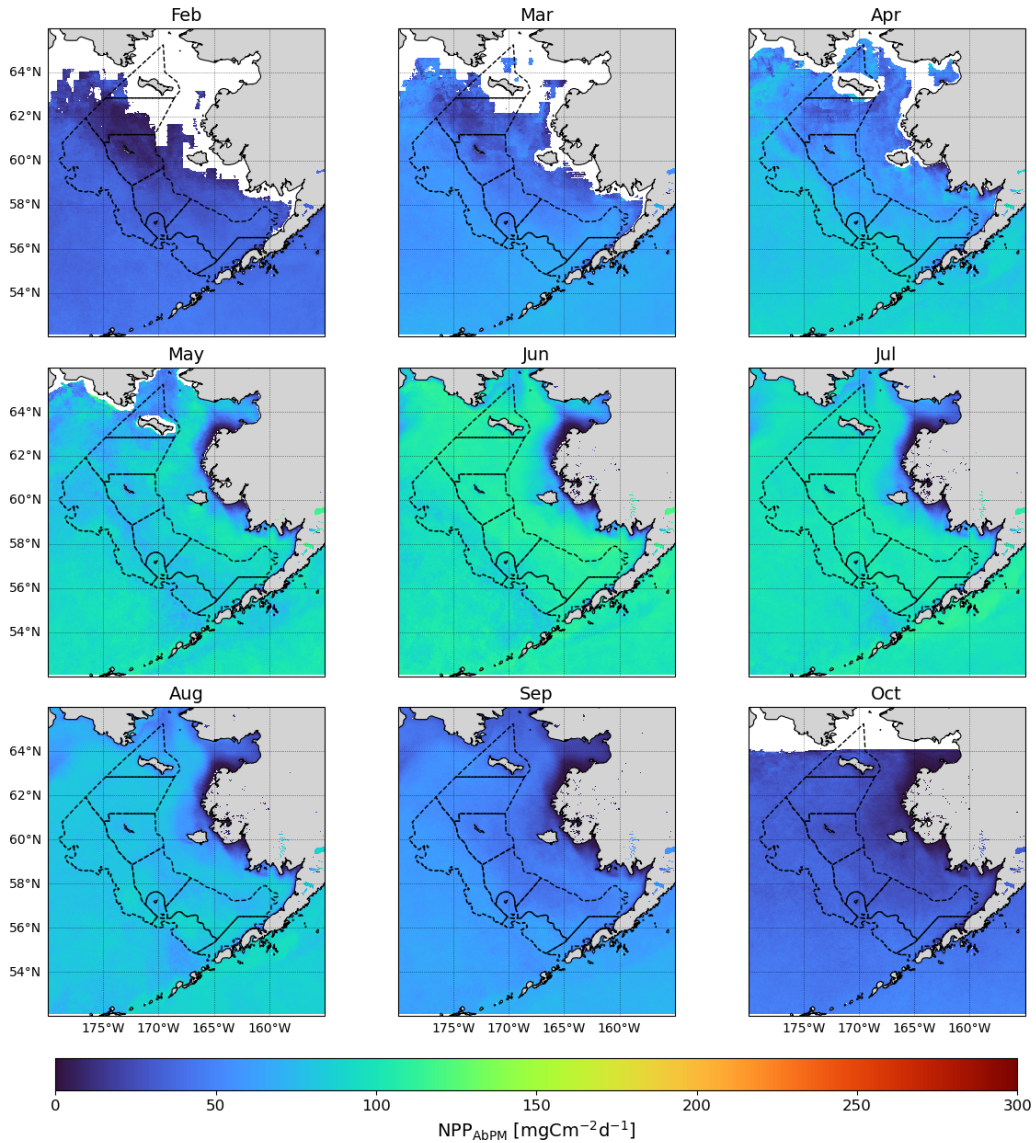
PSC-AbPM climatology

Results (PSC-NPP)

Micro AbPM climatology

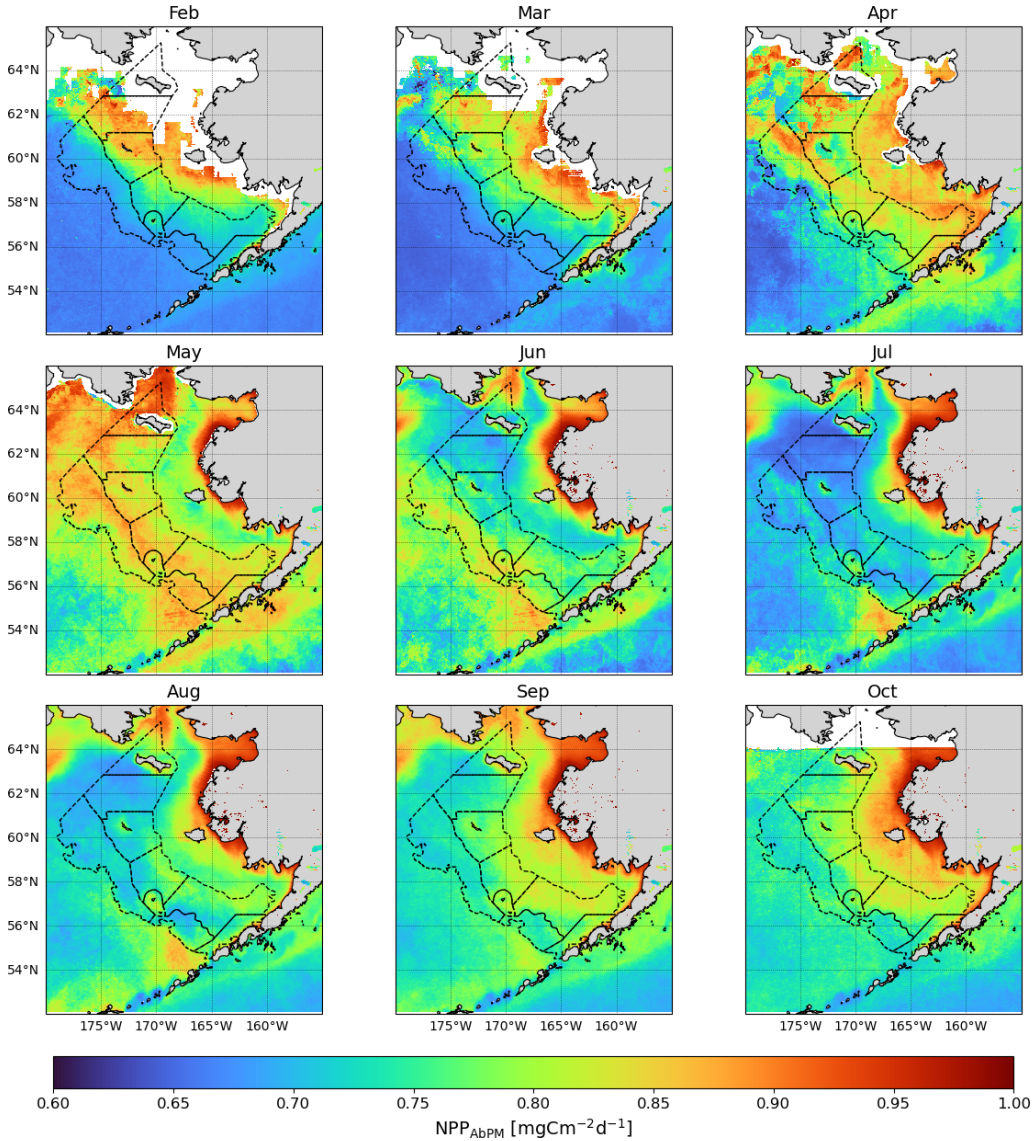


Pico AbPM climatology

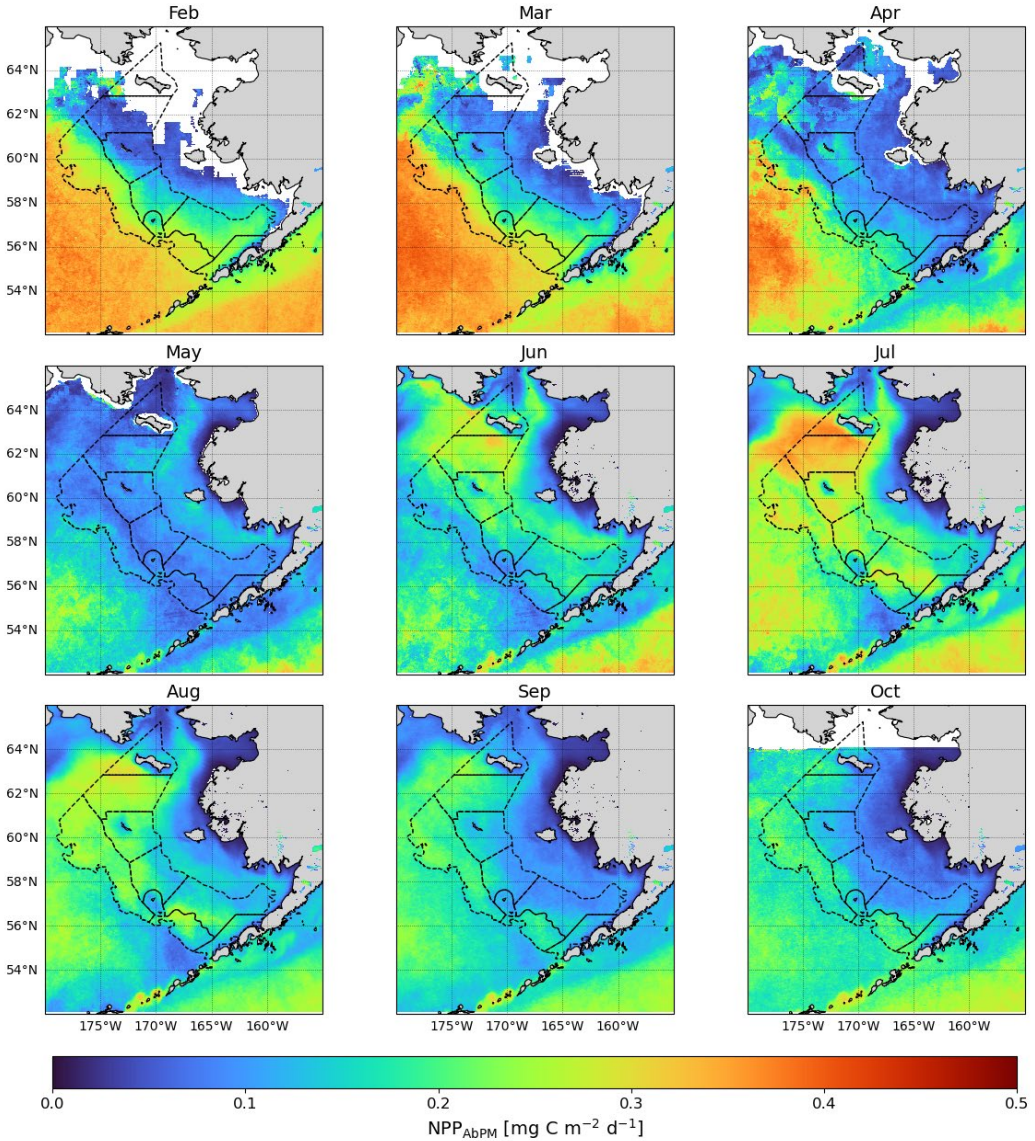


Results (PSC-NPP)

Fractional Micro contribution climatology

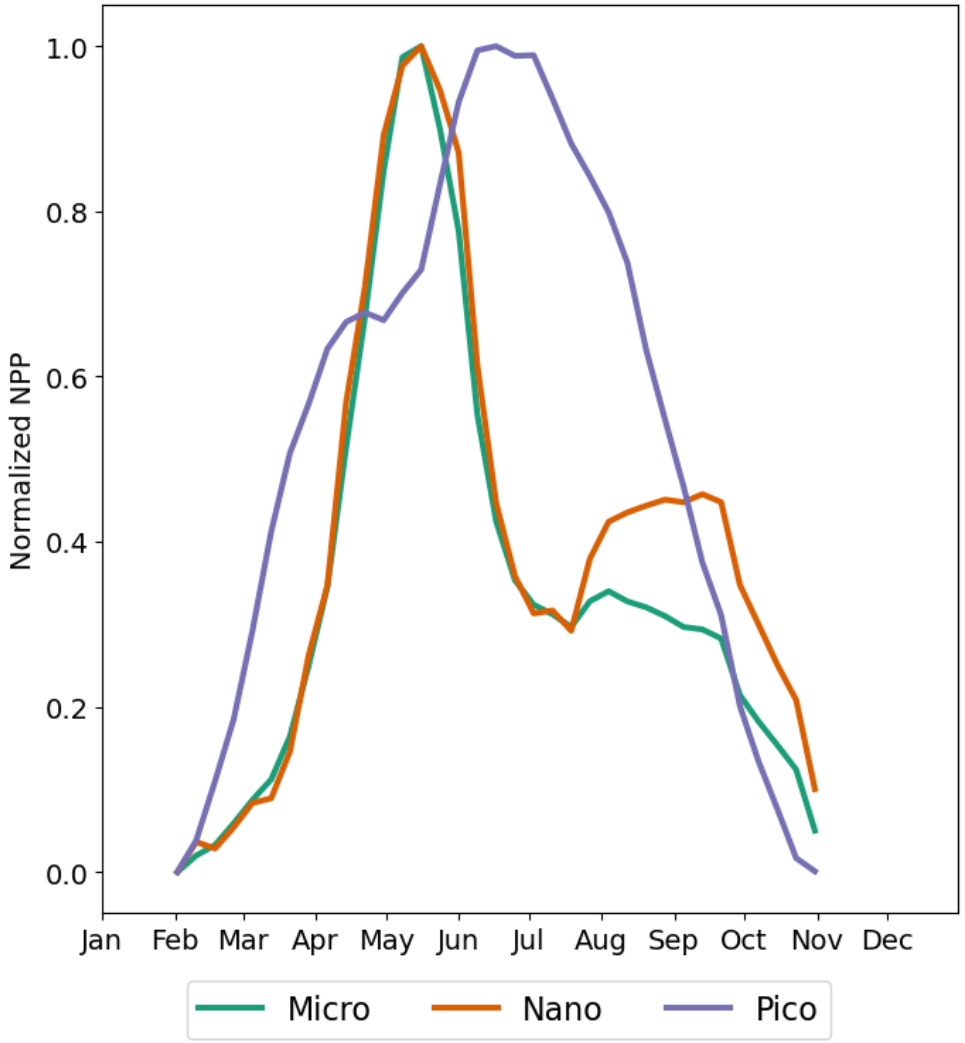


Fractional Pico contribution climatology



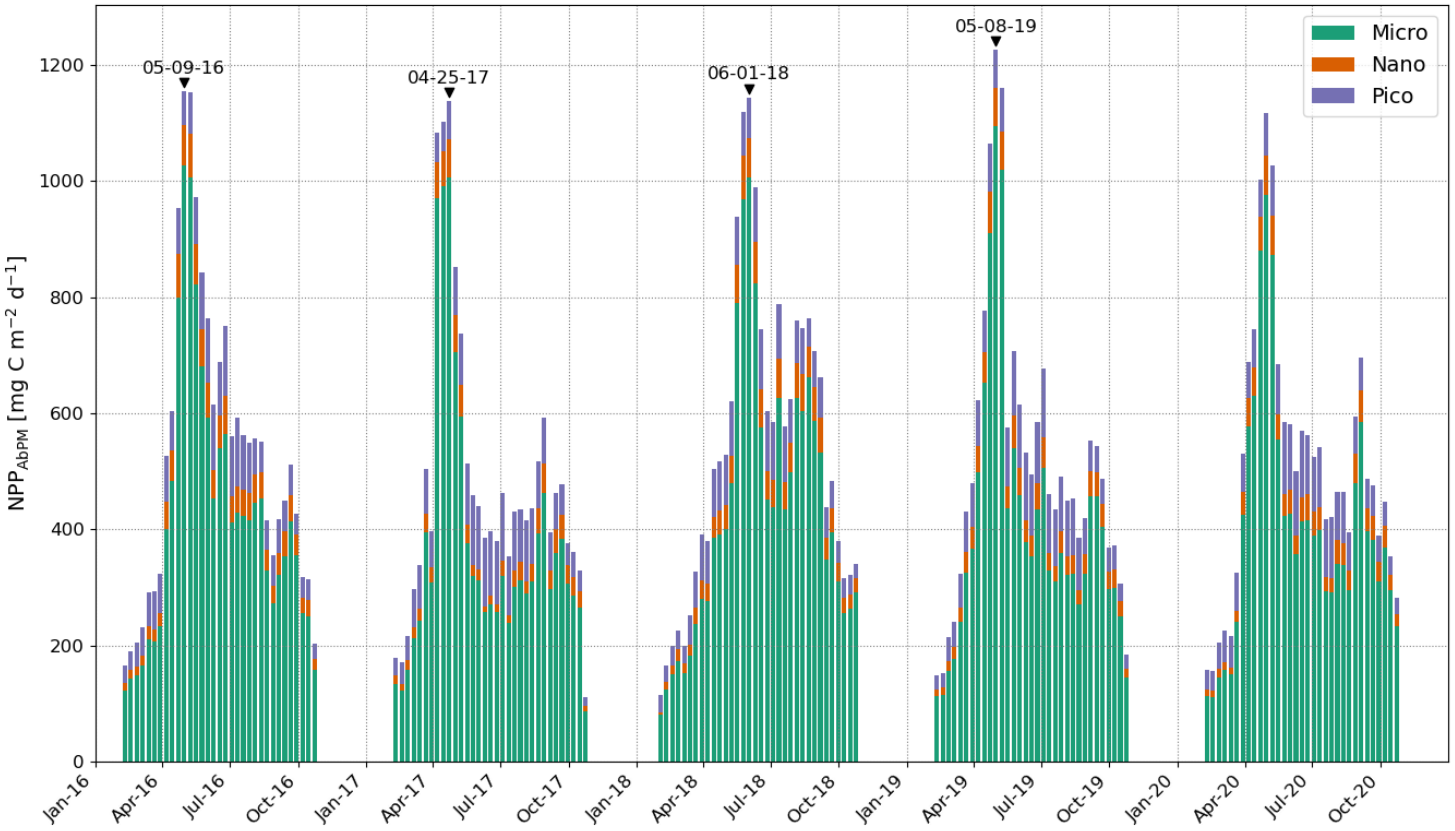
Results (PSC-NPP)

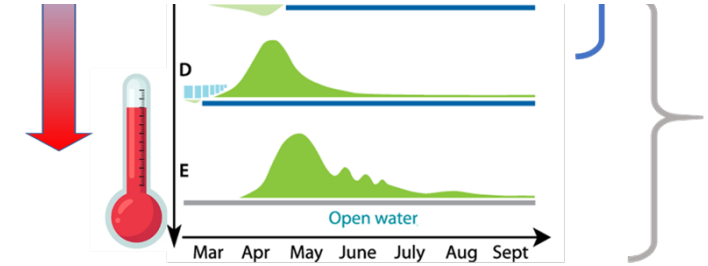
2002-2023 climatology (Mid shelf)



Results (PSC-NPP and ice extent)

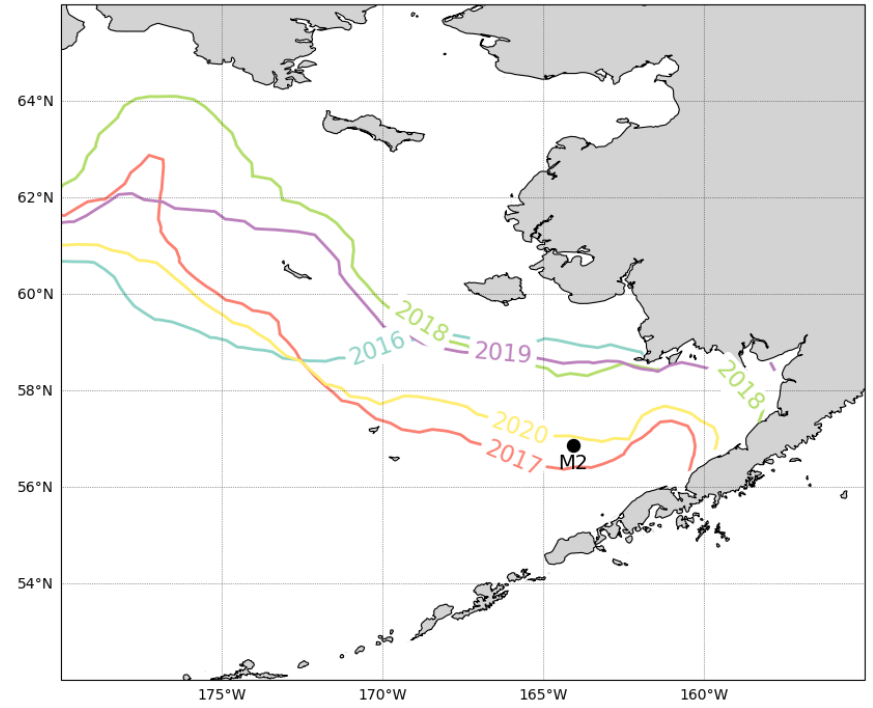
Domain 3 (M2 station) 2016-2020 PSC-AbPM



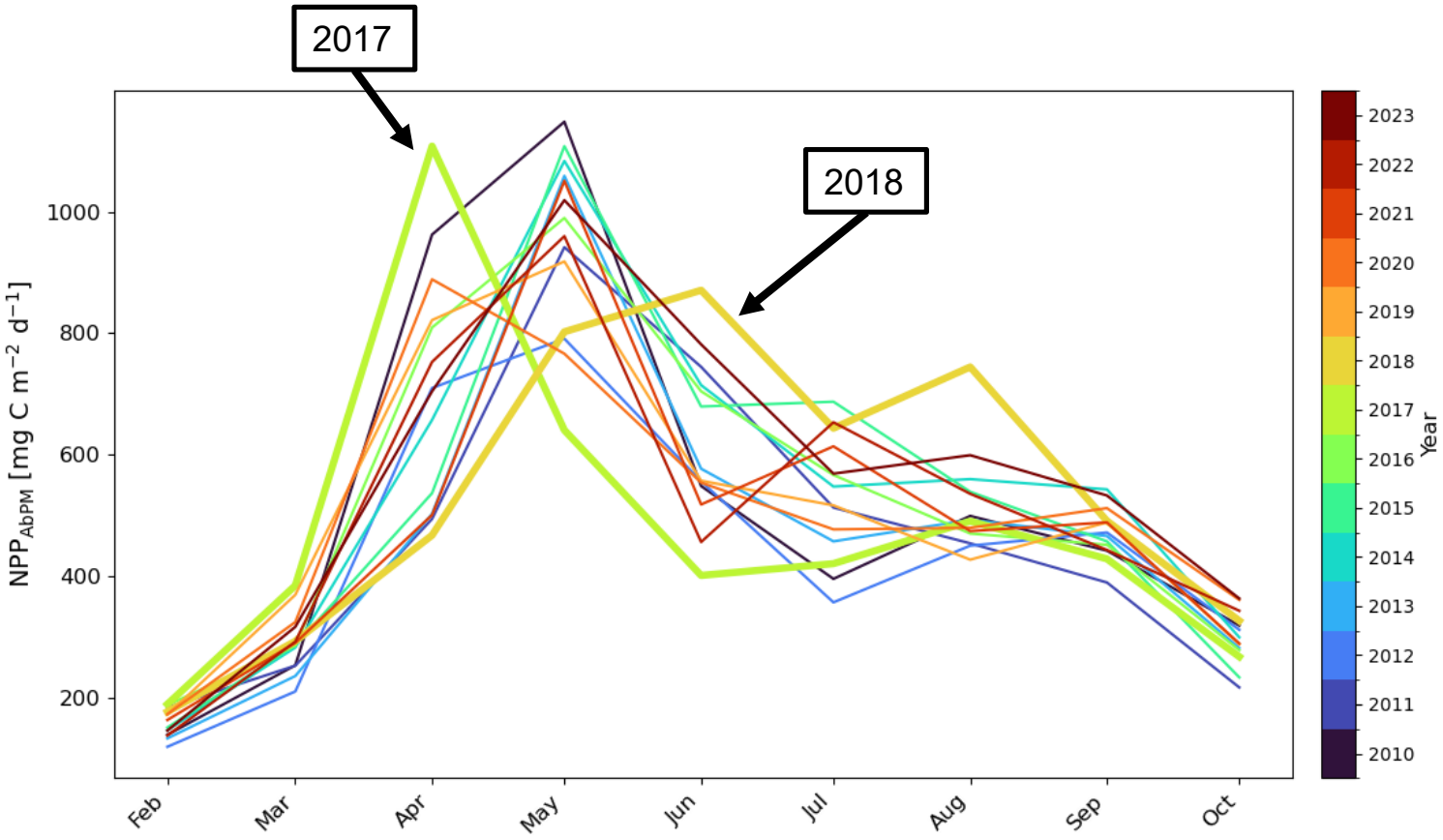


Wassmann & Reigstad 2011

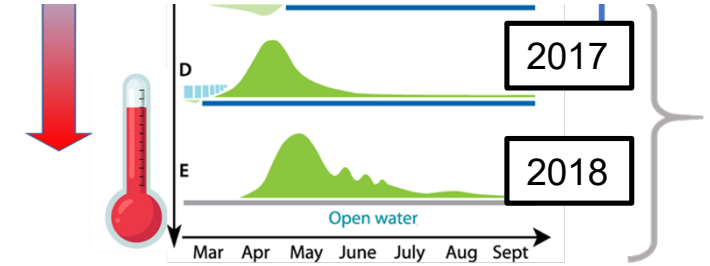
Max ice extent per year



Results (PSC-NPP and ice extent)

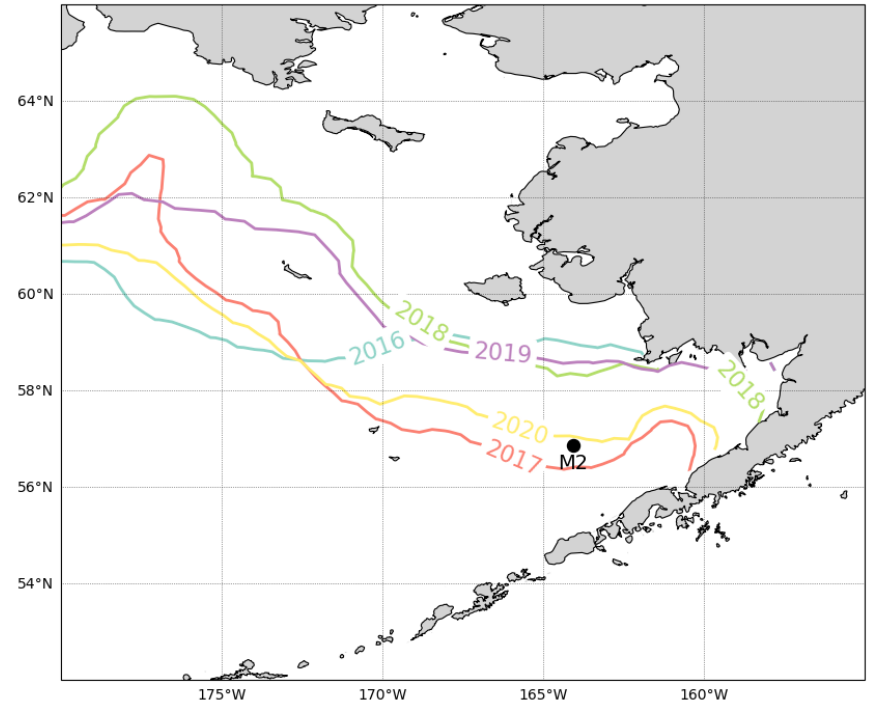


Domain 3 (M2 station) monthly PSC-AbPM



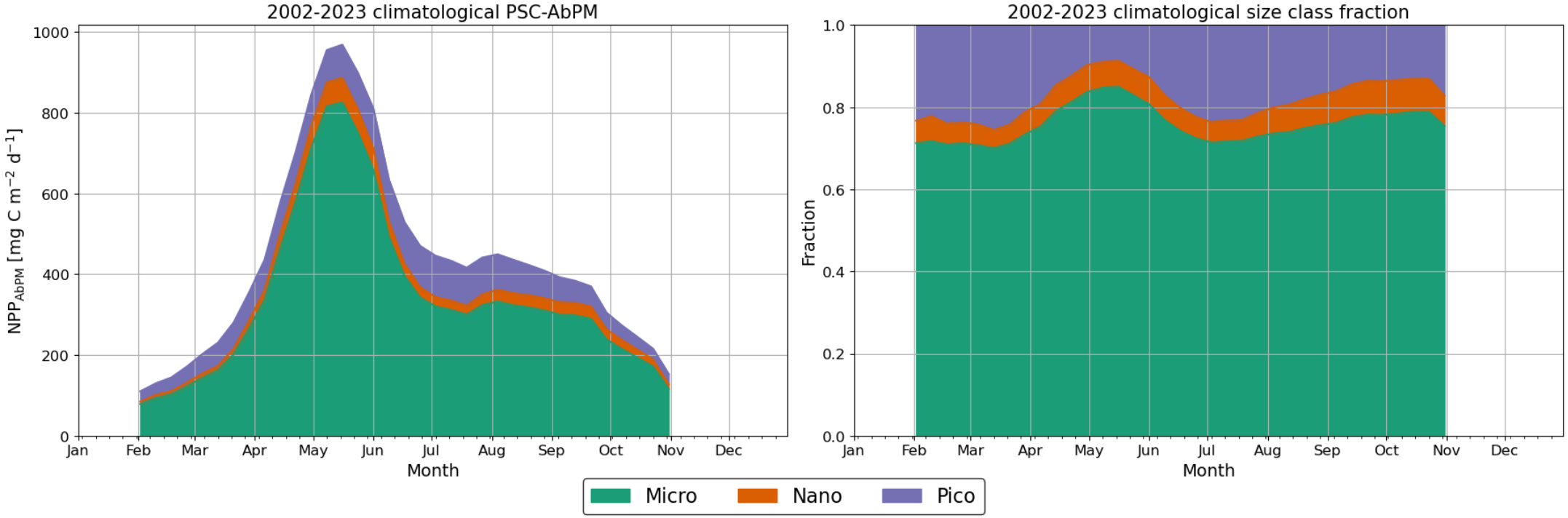
Wassmann & Reigstad 2011

Max ice extent per year

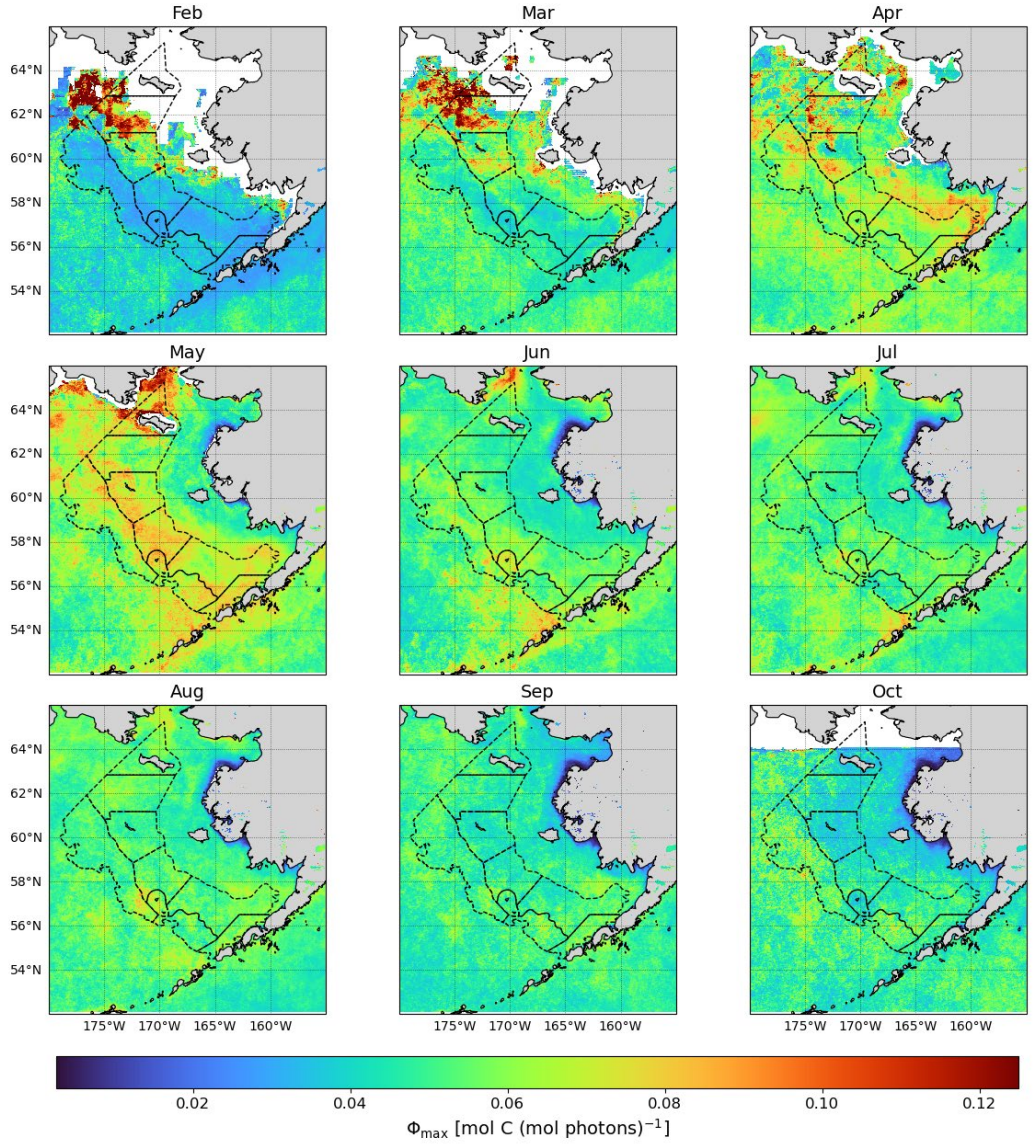


Thank you

jonathan.sherman@noaa.gov


2002-2023 climatological PSC-AbPM
NPP_{AbPM} [mg C m^{-2} d^{-1}]
1000
800
600
400
200
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month
2002-2023 climatological size class fraction
Fraction
1.0
0.8
0.6
0.4
0.2
0.0
Month
Micro
Nano
Pico

Results (Size Class ϕ_{PSC})



ϕ_{max}^{micro} climatology

Size class photophys calc

The maximum quantum yield for carbon fixation was calculated as follows:

$$\Phi_{cmax} = \alpha^B / 12000 \bar{a}^* \quad (4)$$

where 12000 is the molar weight (mg) of carbon, and $\bar{a}^*$ (m^2 (mg Chl a)$^{-1}$) is the mean chlorophyll-specific absorption coefficient of algae, weighted by the spectral distribution [E(λ)] of the PAR used during the P versus E experiments.

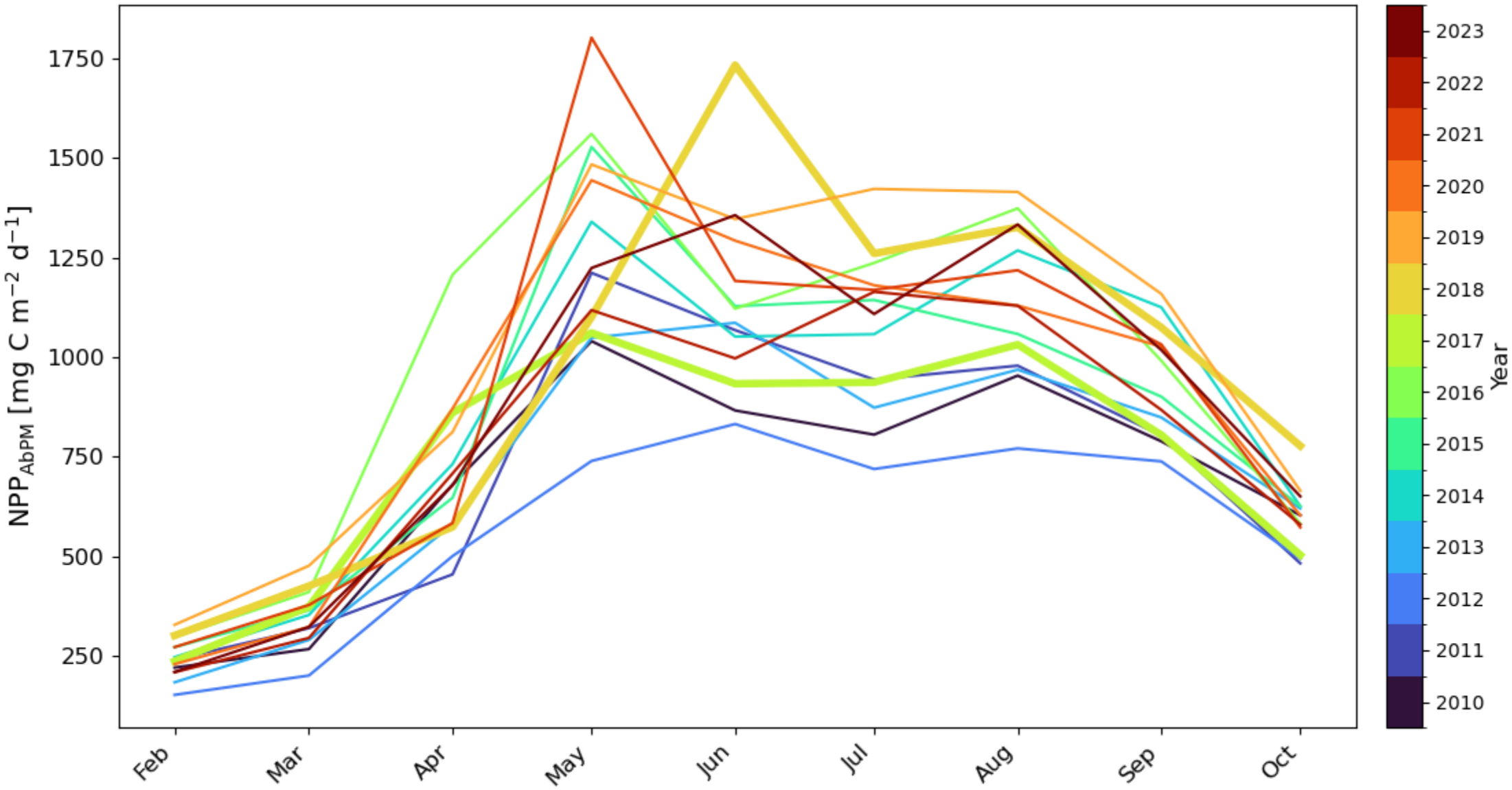
$$\bar{a}^* = \frac{\int_{400}^{700} a^*(\lambda)E(\lambda)d\lambda}{\int_{400}^{700} E(\lambda)d\lambda} \quad (5)$$

$$x^* = (1/[\text{Chl } a])([\text{Chl } a]_{micro} x^*_{micro}(0) e^{-s_{micro} z/Z_{eu}} + [\text{Chl } a]_{nano} x^*_{nano}(0) e^{-s_{nano} z/Z_{eu}} + [\text{Chl } a]_{pico} x^*_{pico}(0) e^{-s_{pico} z/Z_{eu}}) \quad (13)$$

In Eq. 13, x* stands for any chlorophyll-normalized parameter (a*, α^B, or P^B_{max}); $x^*_{micro}(0)$, $x^*_{nano}(0)$, and $x^*_{pico}(0)$ represent any chlorophyll-normalized parameter at the surface, specific to micro-, nano-, and picophytoplankton, respectively; and s_{micro}, s_{nano}, and s_{pico} are the slopes describing the variations of the photophysiological parameters along the vertical z/Z_{eu} axis.

Phimax is limited to realistic bounds→ $0 < \phi \leq 1.25$

Uitz et. al., 2008



Domain 3 (M2 station) monthly VGPM