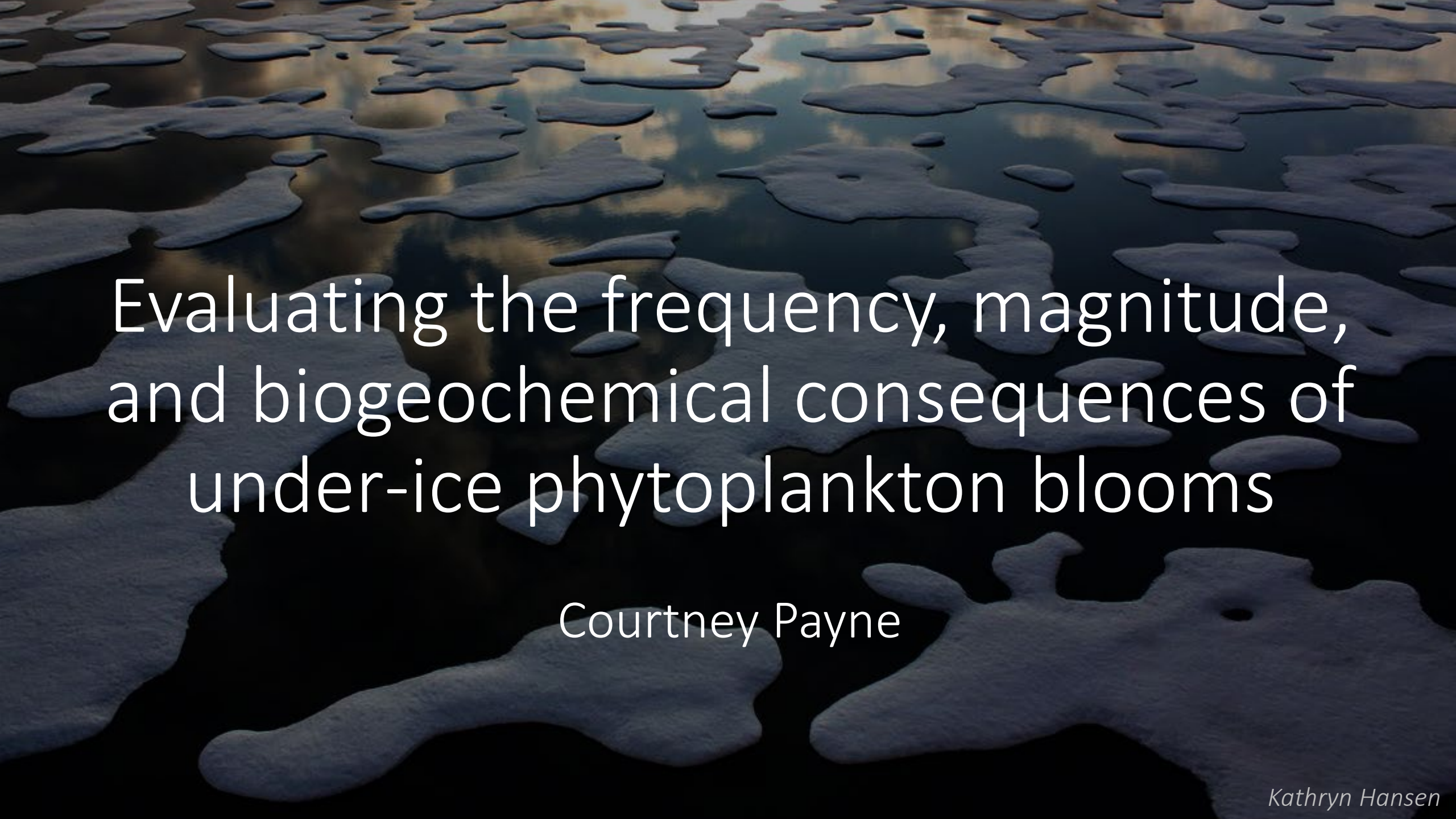
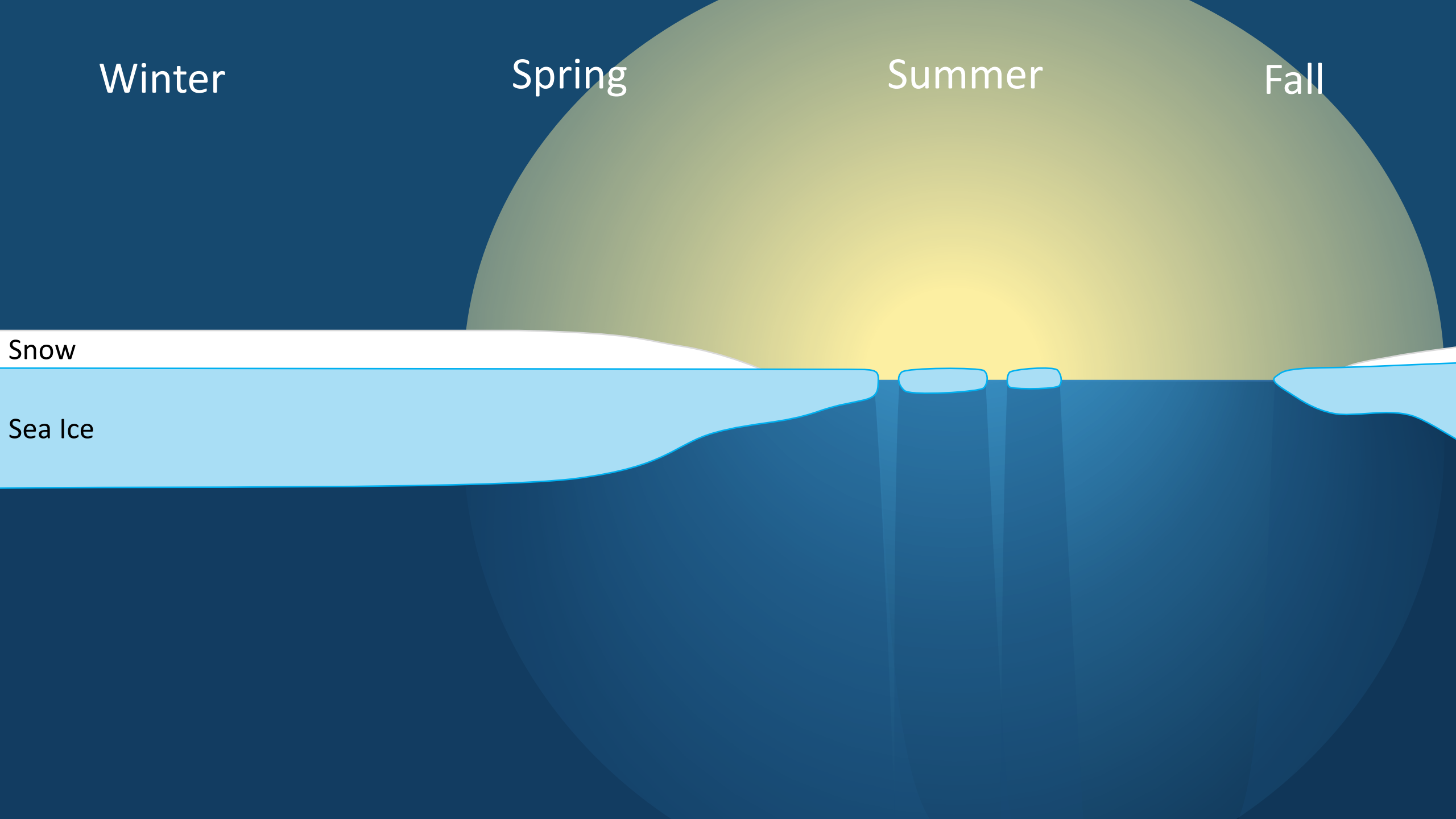
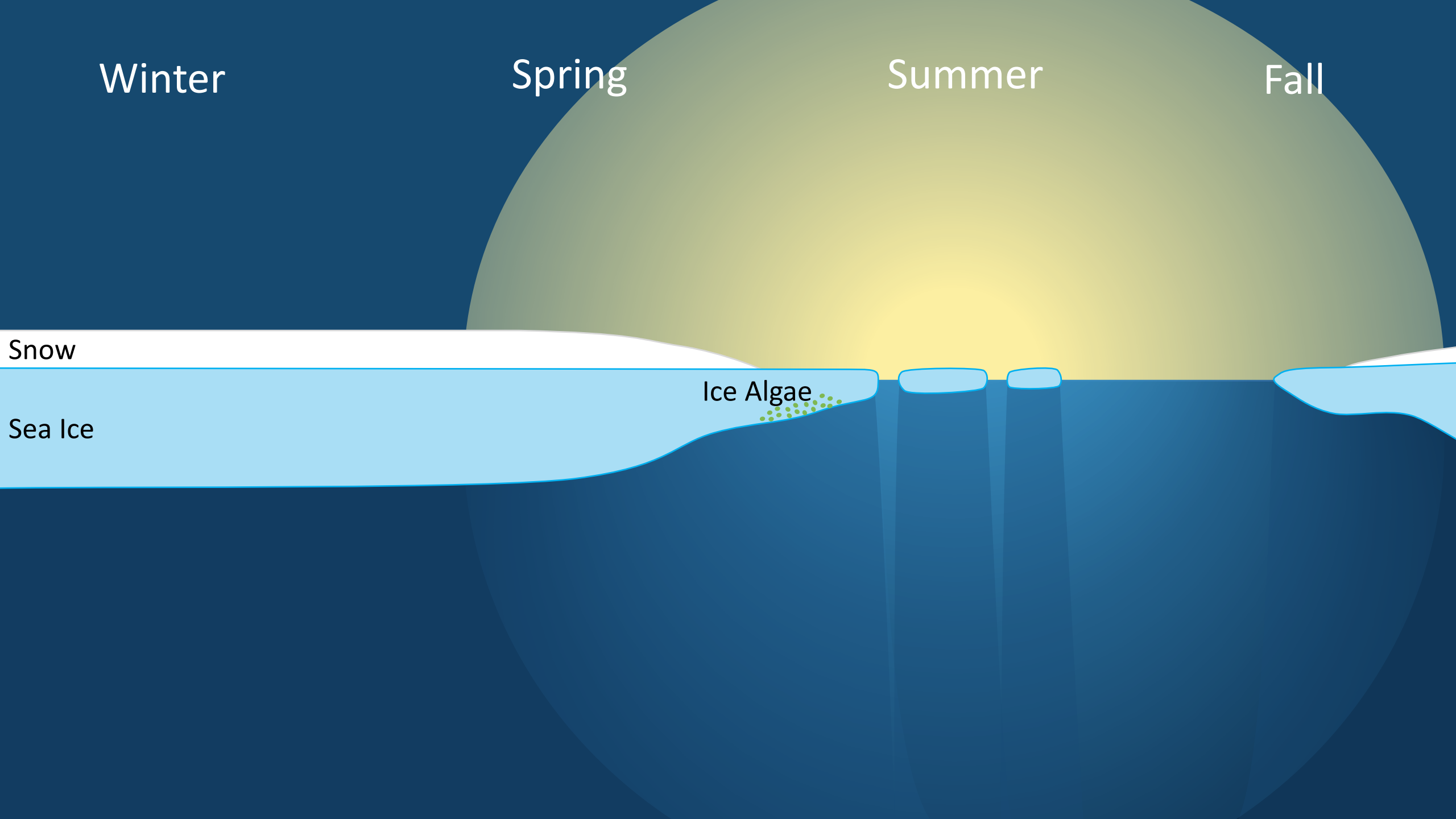


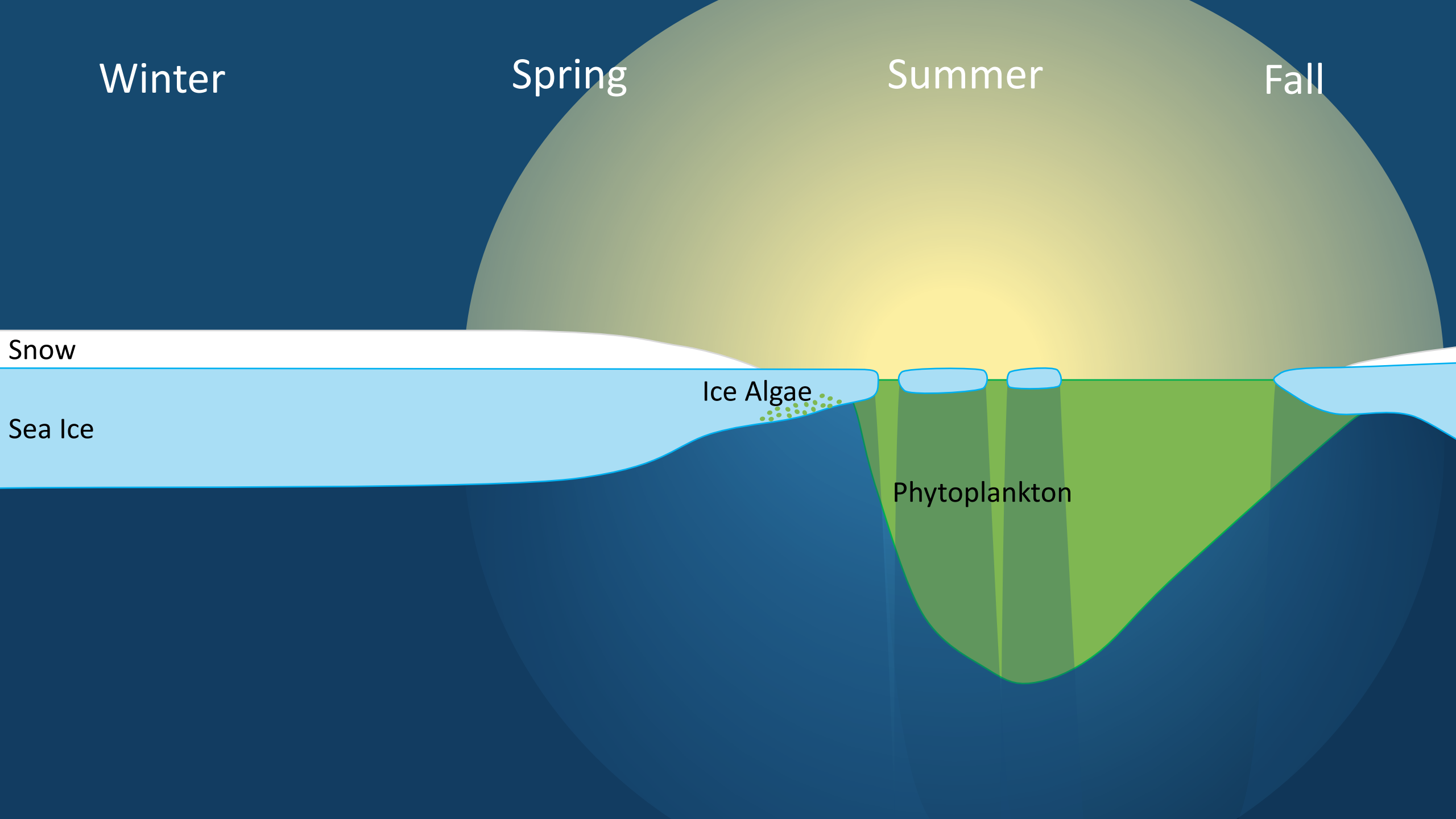
Evaluating the frequency, magnitude, and biogeochemical consequences of under-ice phytoplankton blooms

Courtney Payne

Kathryn Hansen


Winter
Spring
Summer
Fall
Snow
Sea Ice

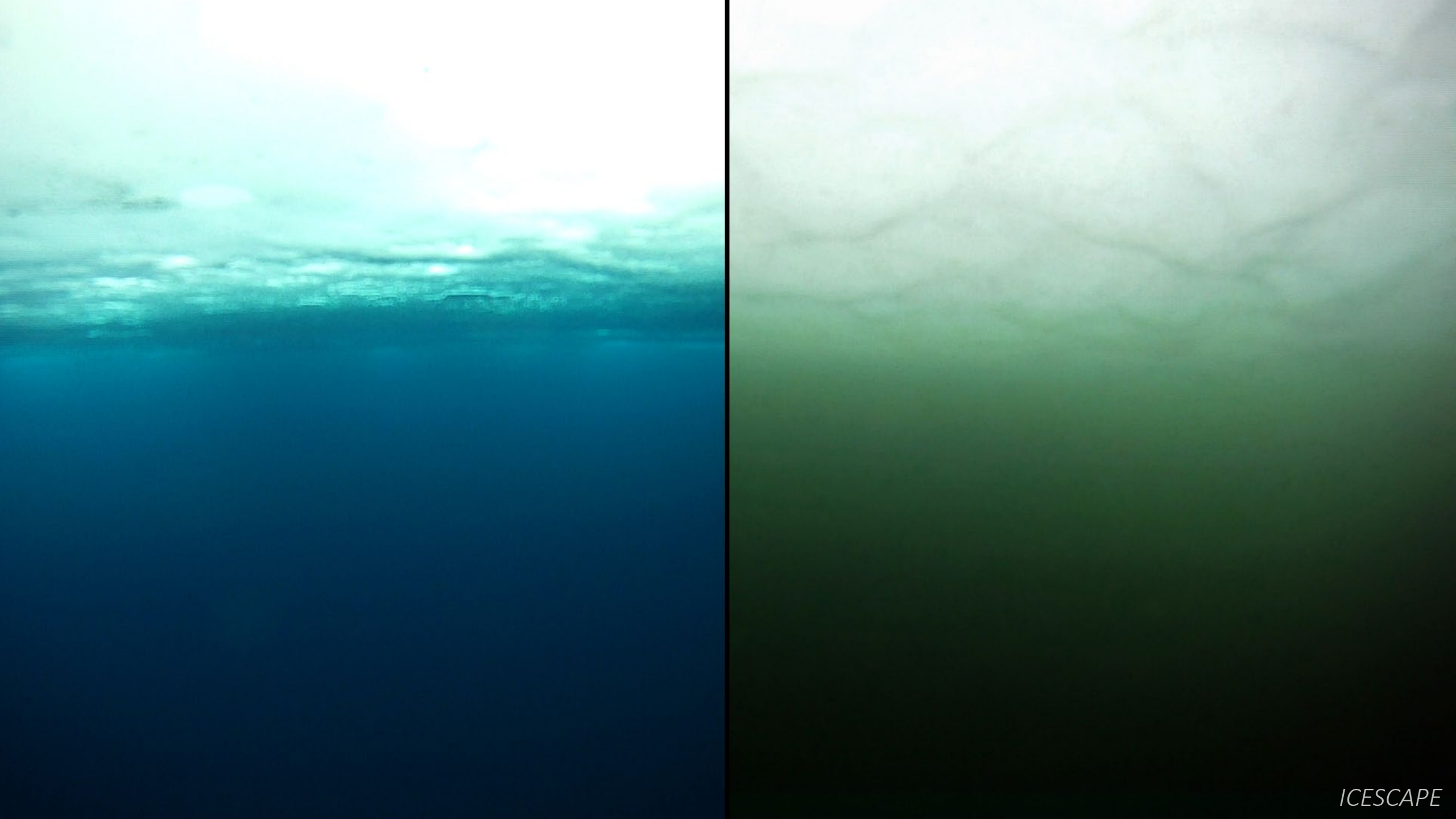

Winter
Spring
Summer
Fall
Snow
Ice Algae
Sea Ice


Winter
Spring
Summer
Fall
Snow
Sea Ice
Ice Algae
Phytoplankton

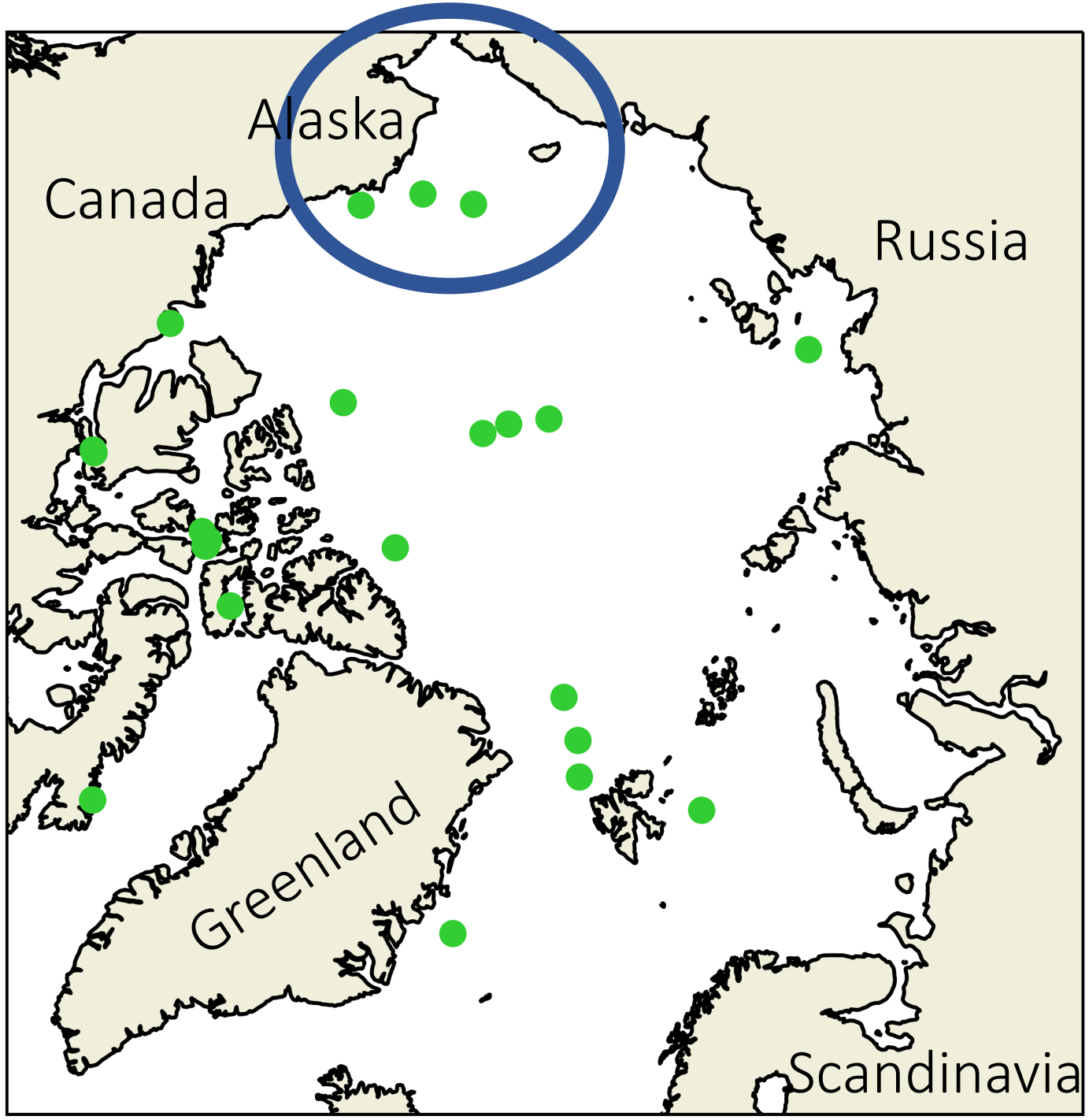
Henrik Blessing


Marcos Porcires

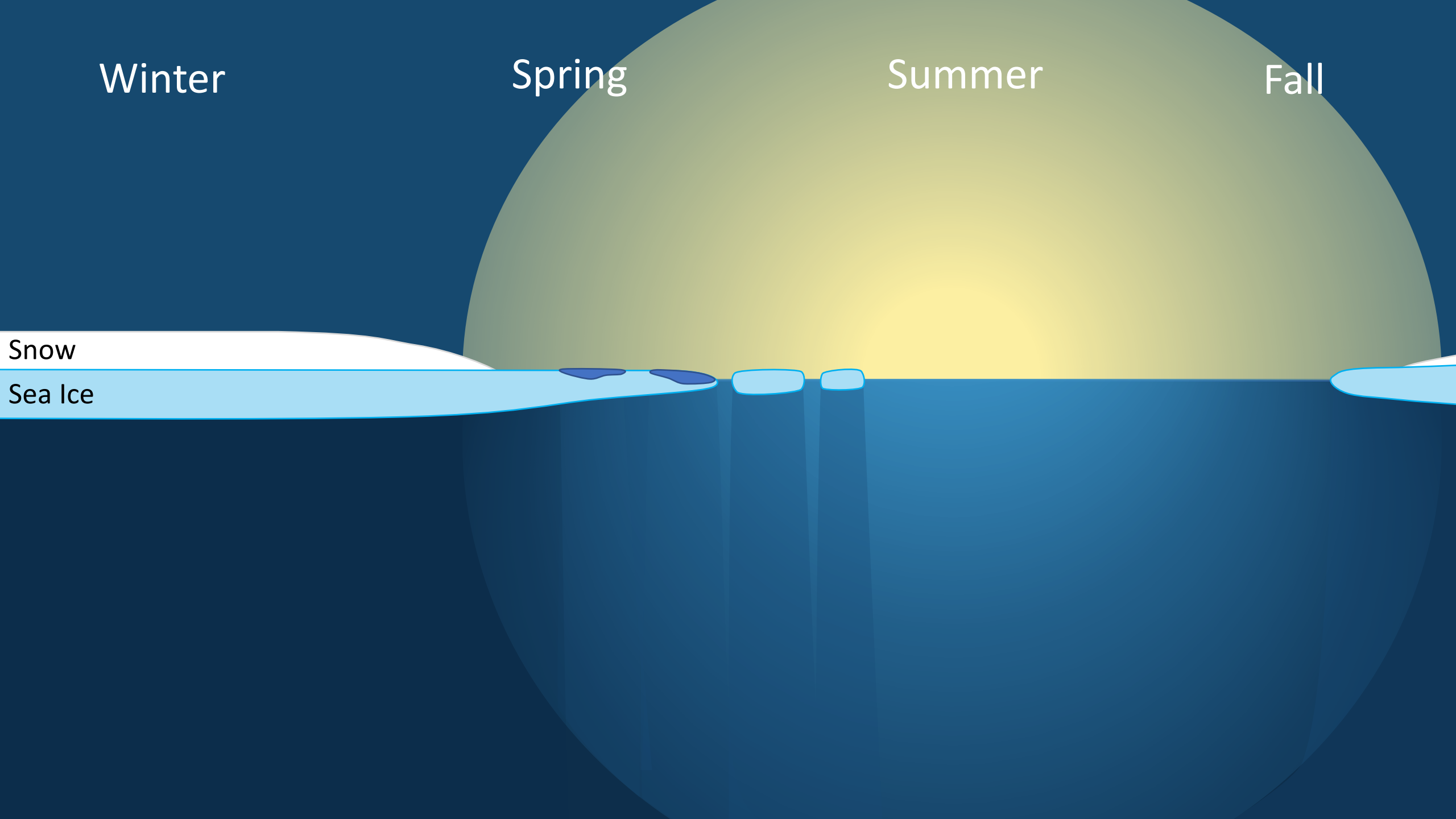

Kathryn Hansen

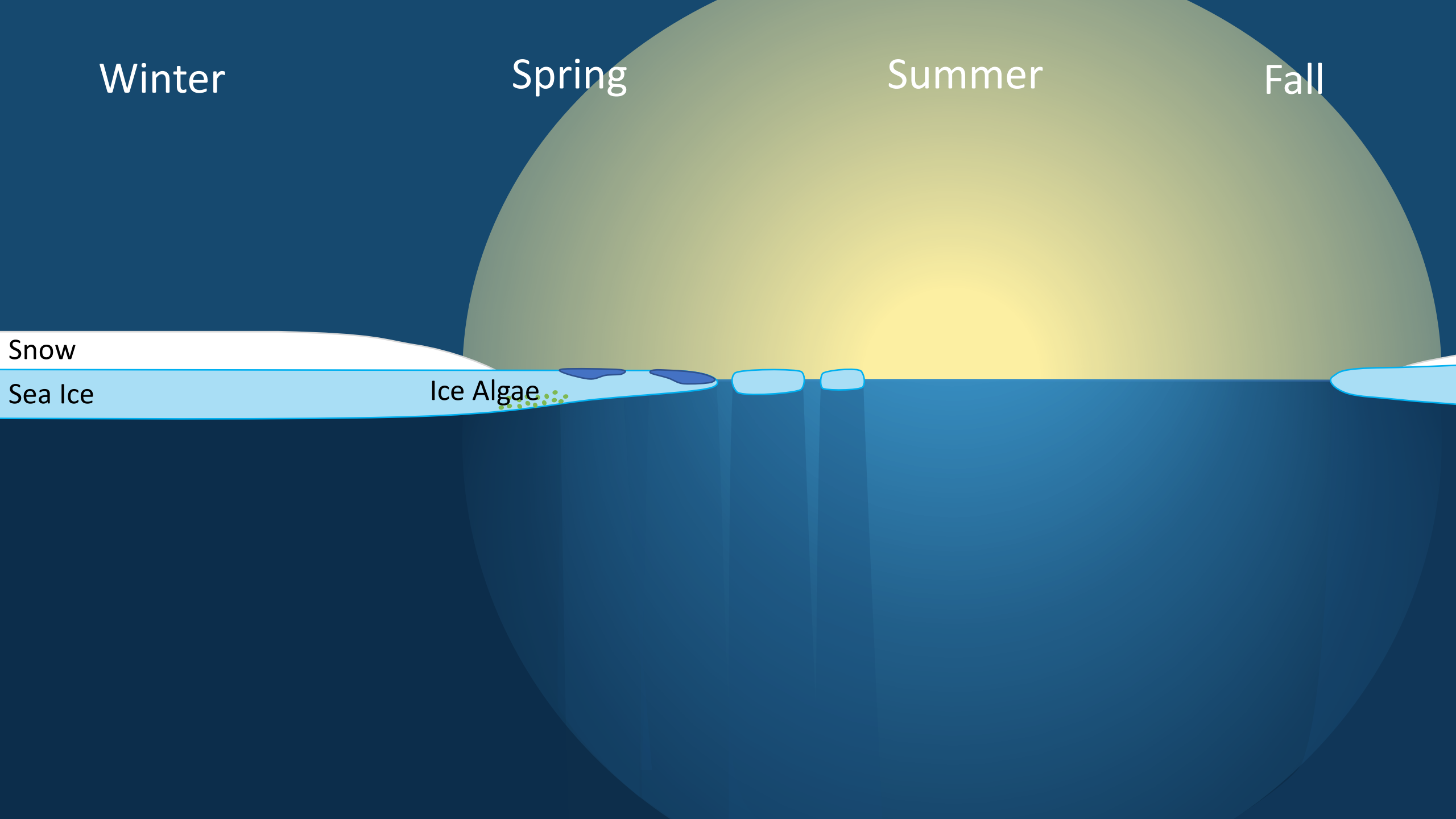

ICESCAPE

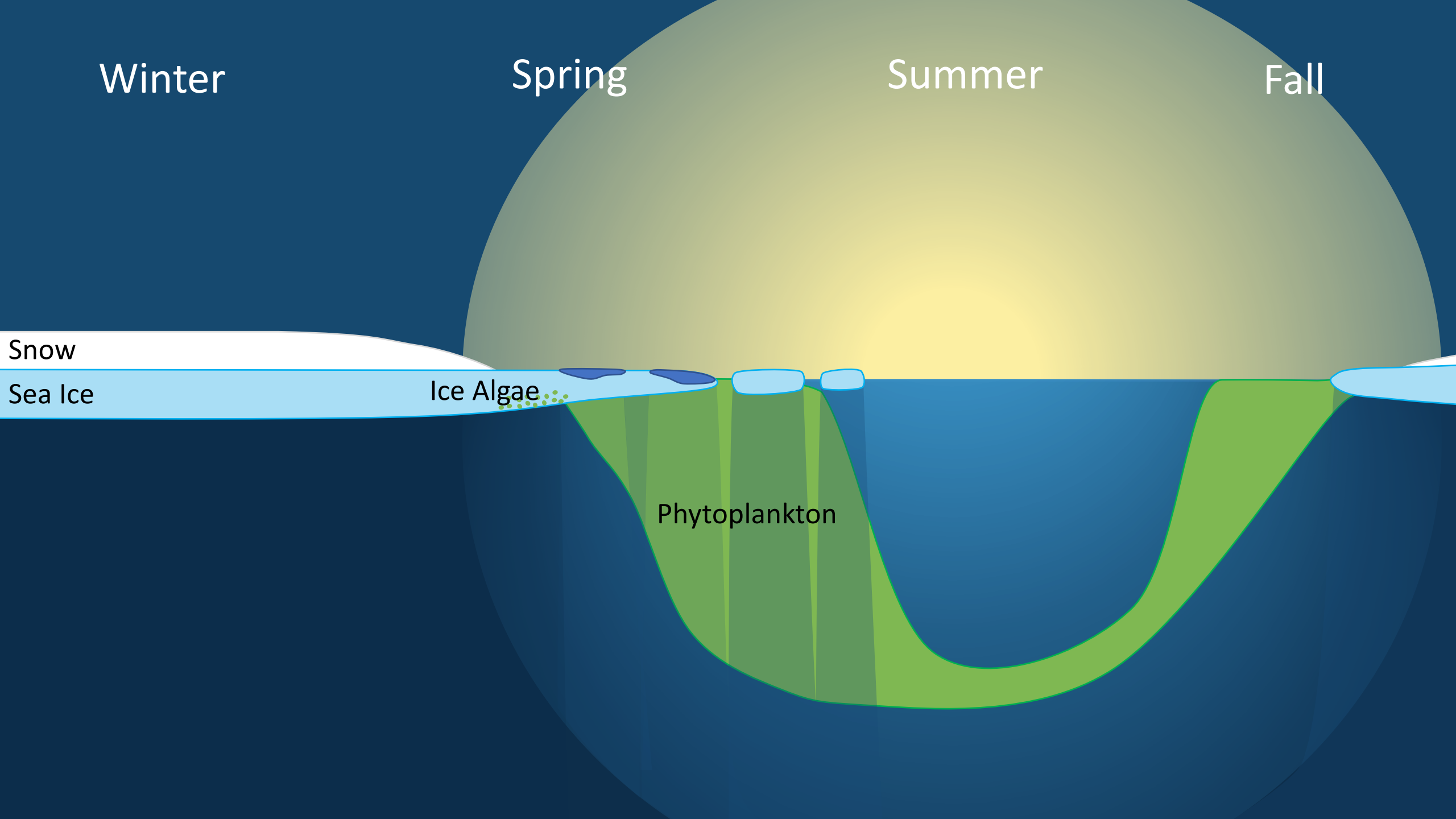

Alaska
Canada
Russia
Chukchi Sea
Greenland
Scandinavia

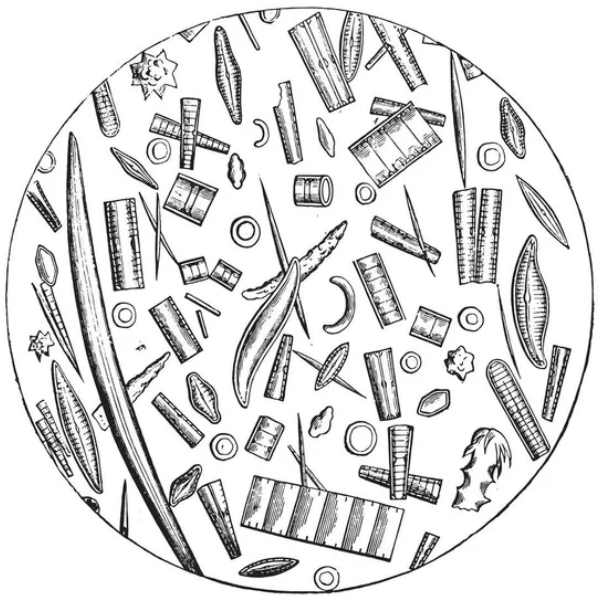


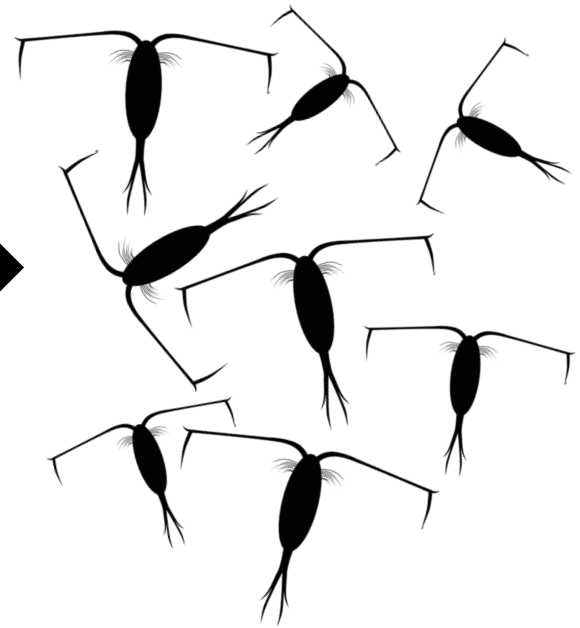
data from
Ardyna et al., 2020

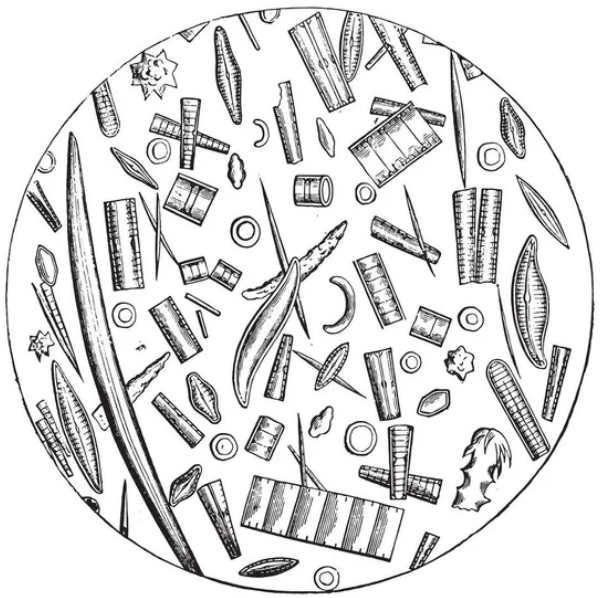

Winter
Spring
Summer
Fall
Snow
Sea Ice

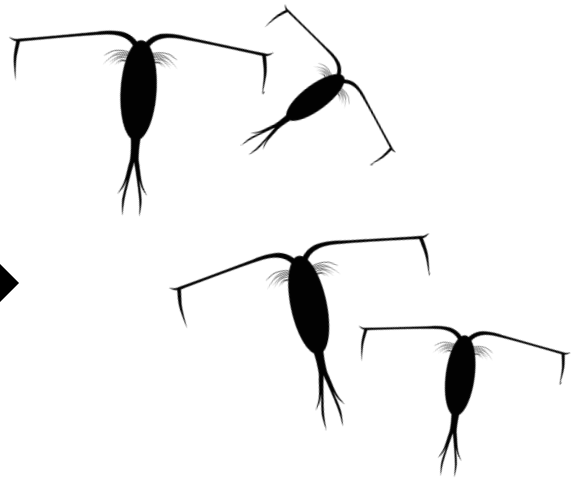

Winter
Spring
Summer
Fall
Snow
Sea Ice
Ice Algae

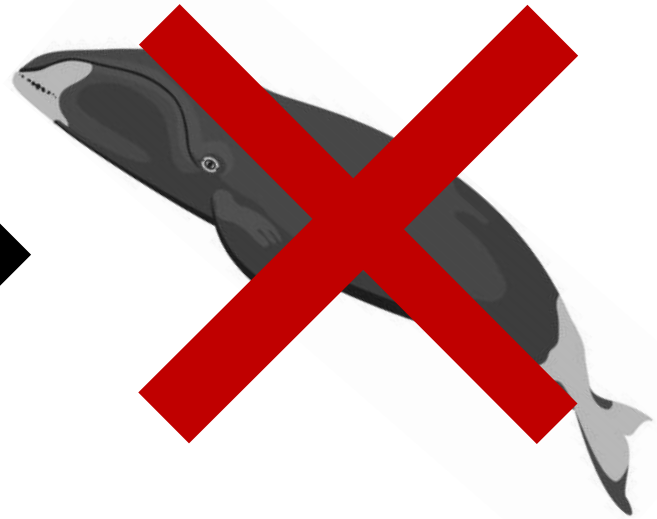

Winter
Spring
Summer
Fall
Snow
Sea Ice
Ice Algae
Phytoplankton











Chukchi Sea

- How much do under-ice (UI) phytoplankton blooms contribute to total net primary production (NPP), and how has this changed over time?
- How do these blooms affect food availability?

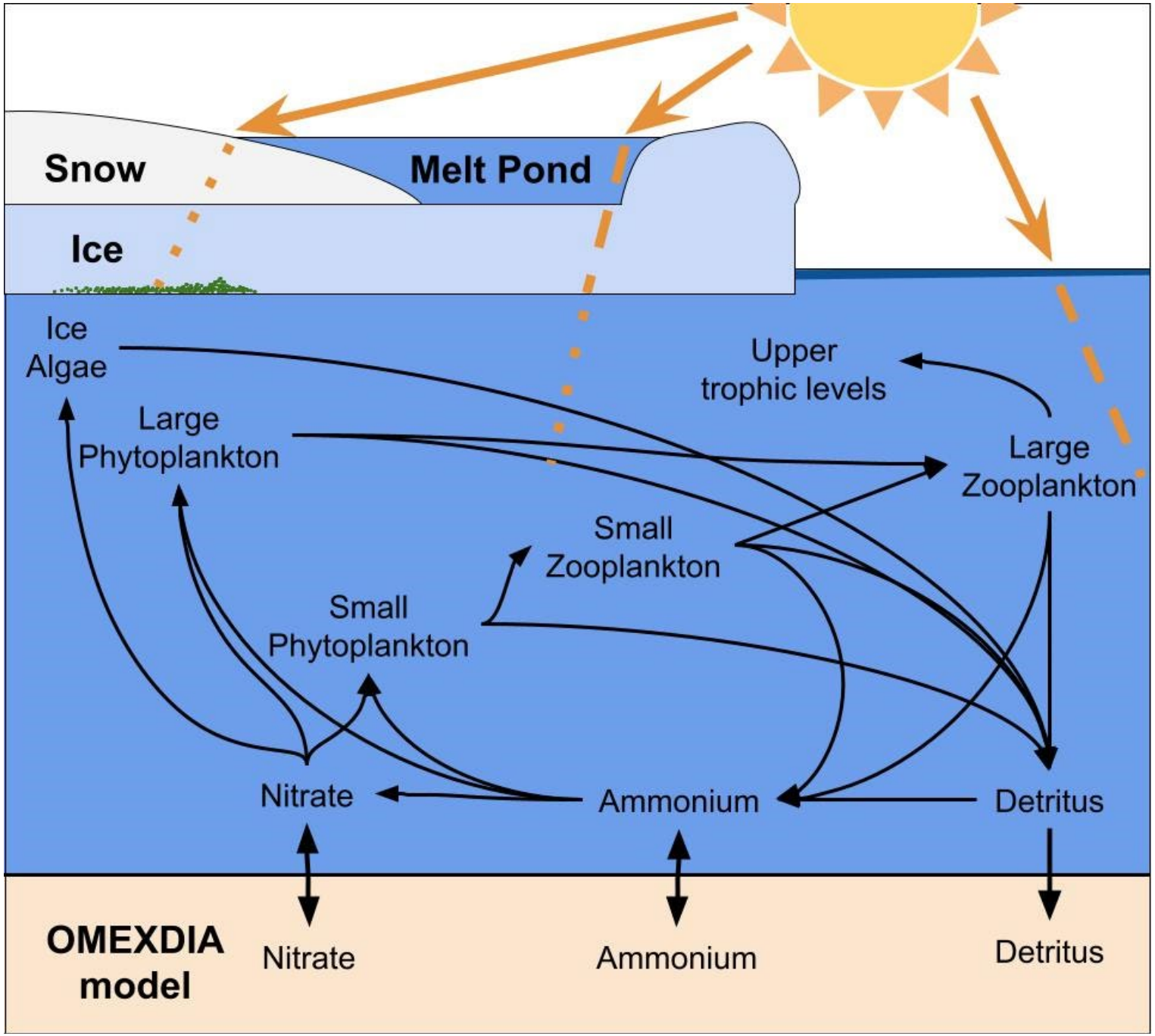
GOTM

Burchard et al. 1999

CAOS MODEL

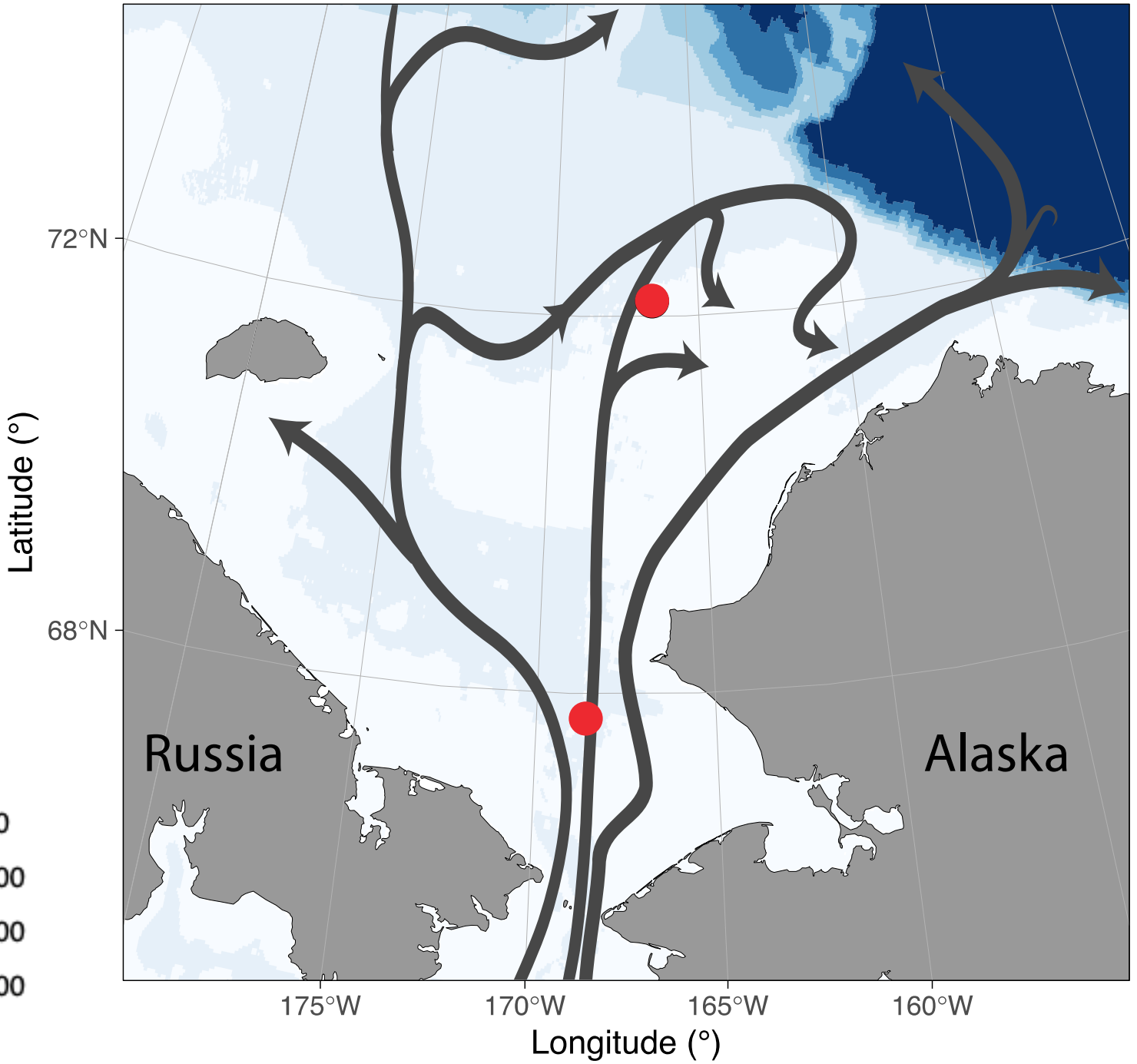
OMEXDIA

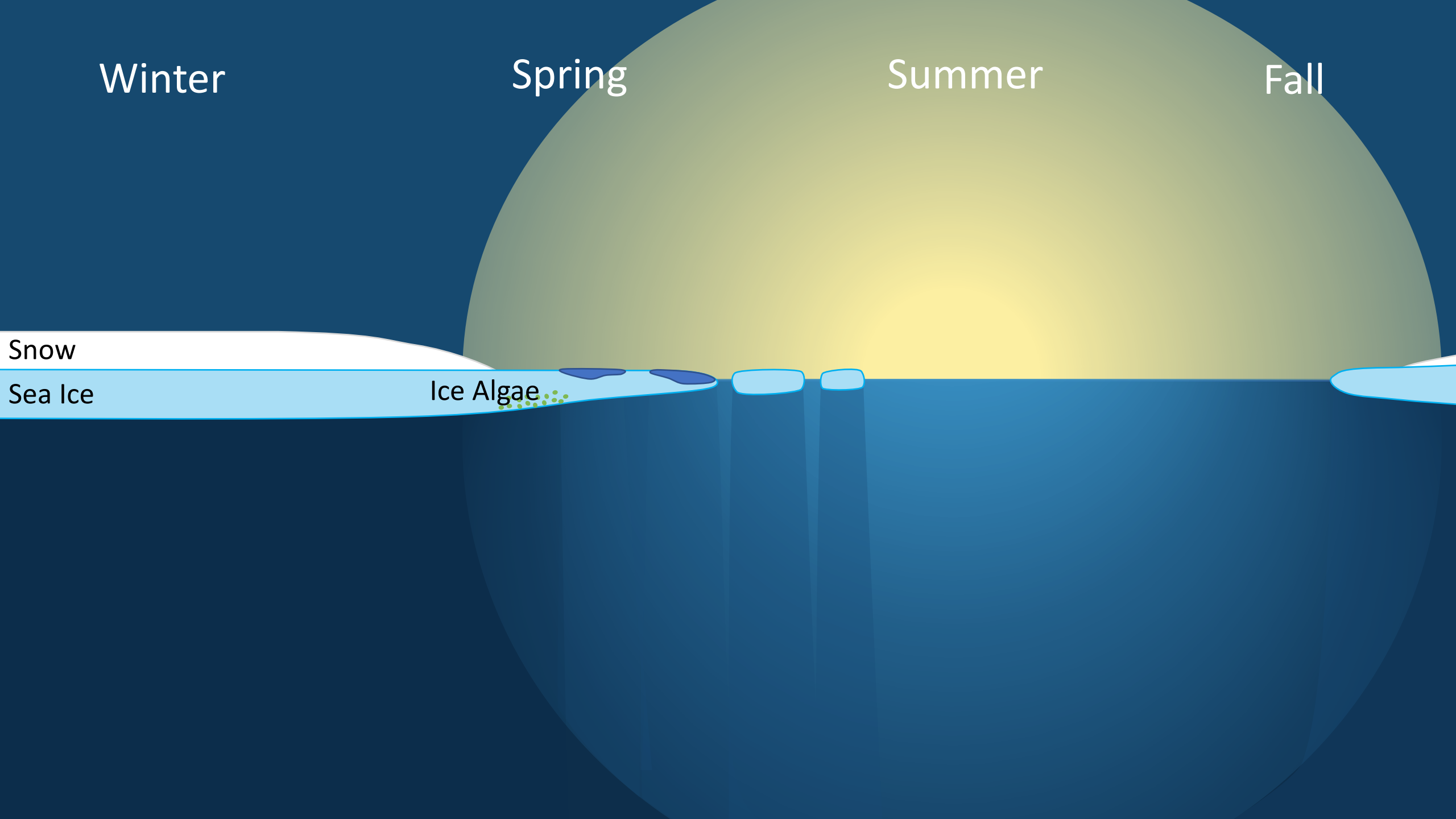
Soetaert et al. 1996

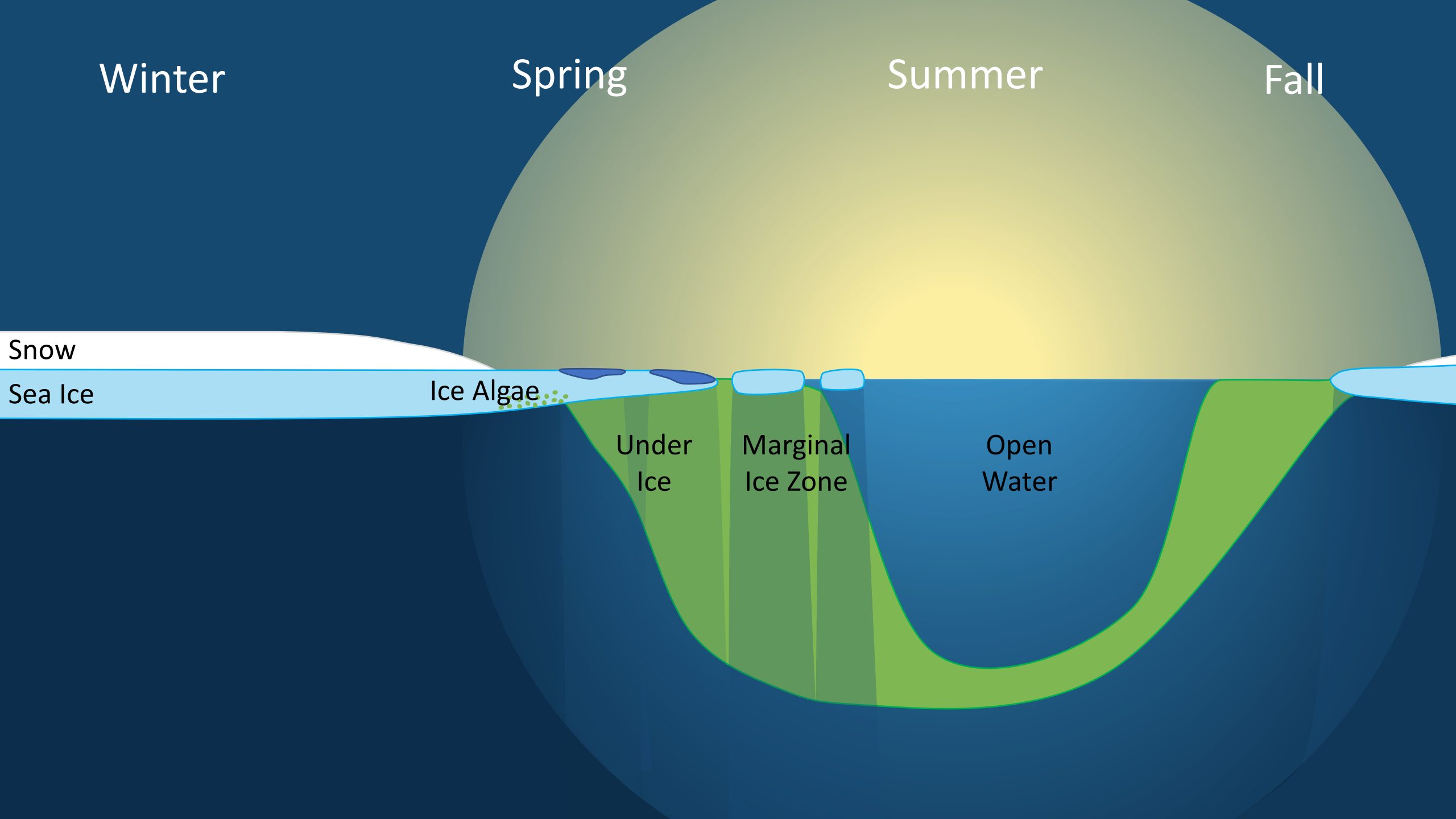


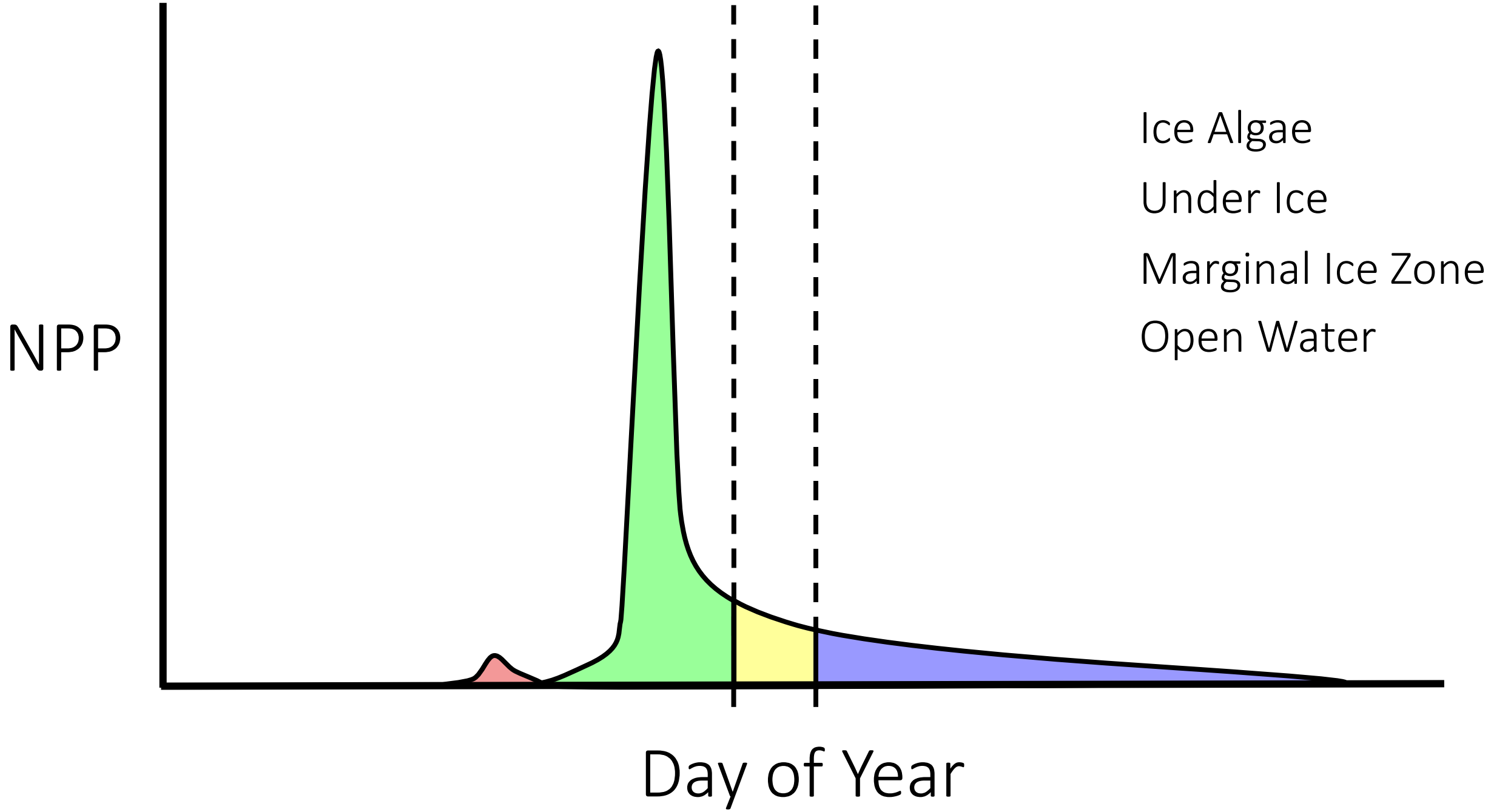
The Chukchi Sea

- Advective pathways
- Northern and Southern Chukchi Sea locations




Winter
Spring
Summer
Fall
Snow
Sea Ice
Ice Algae


Winter
Spring
Summer
Fall
Snow
Sea Ice
Ice Algae
Under Ice
Marginal Ice Zone
Open Water

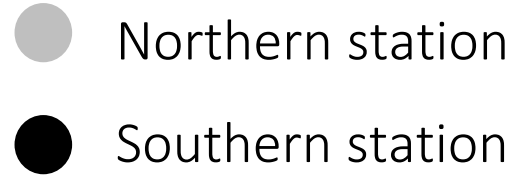

NPP
Ice Algae
Under Ice
Marginal Ice Zone
Open Water
Day of Year

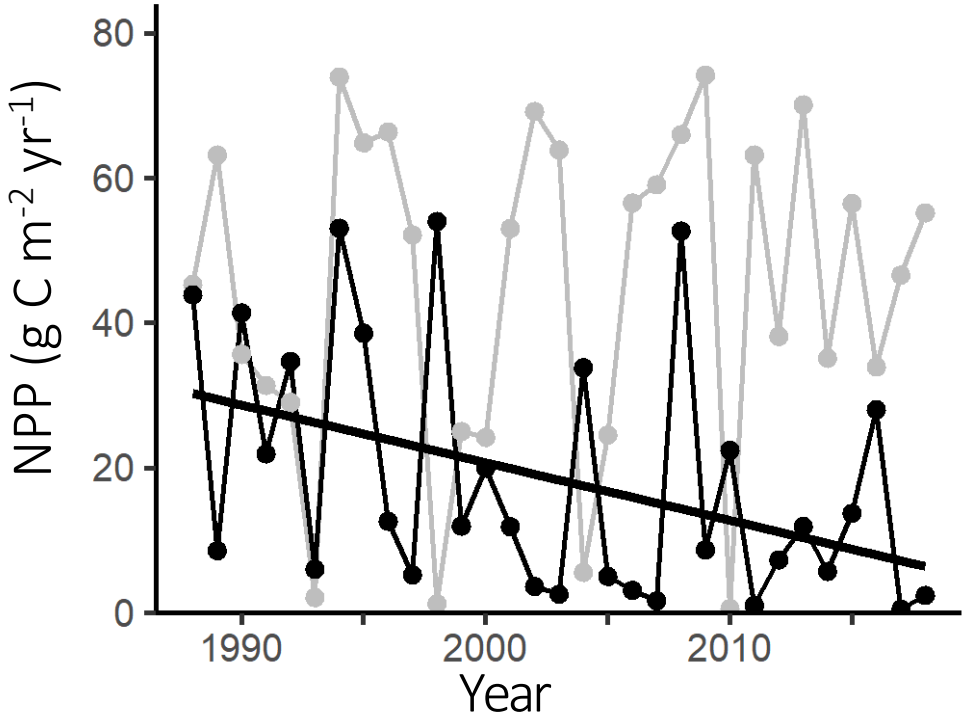
Under Ice period: 14 days longer in the northern than the southern Chukchi Sea, where it was diminishing

Growing Season	North (d)	South (d)	Diff. (d)
Under Ice	42	28 ↓	14

Under Ice NPP: 1.5 times greater in the northern than the southern Chukchi Sea, where it was diminishing

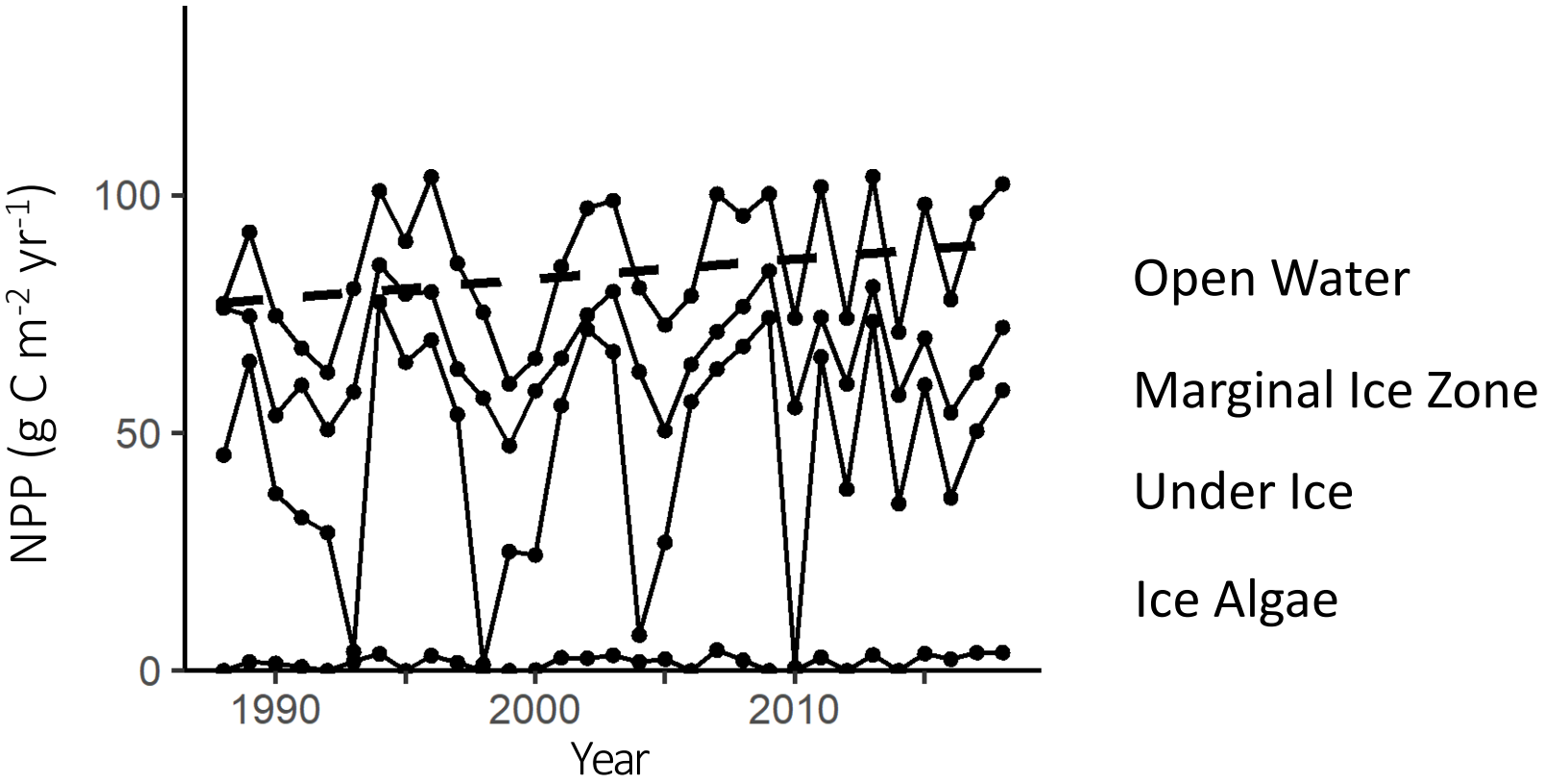
Growing Season	North (d)	South (d)	Diff. (d)
Under Ice	42	28 ↓	14





In the north, total NPP was dominated by under-ice production and increased over time

North



Open Water

Marginal Ice Zone

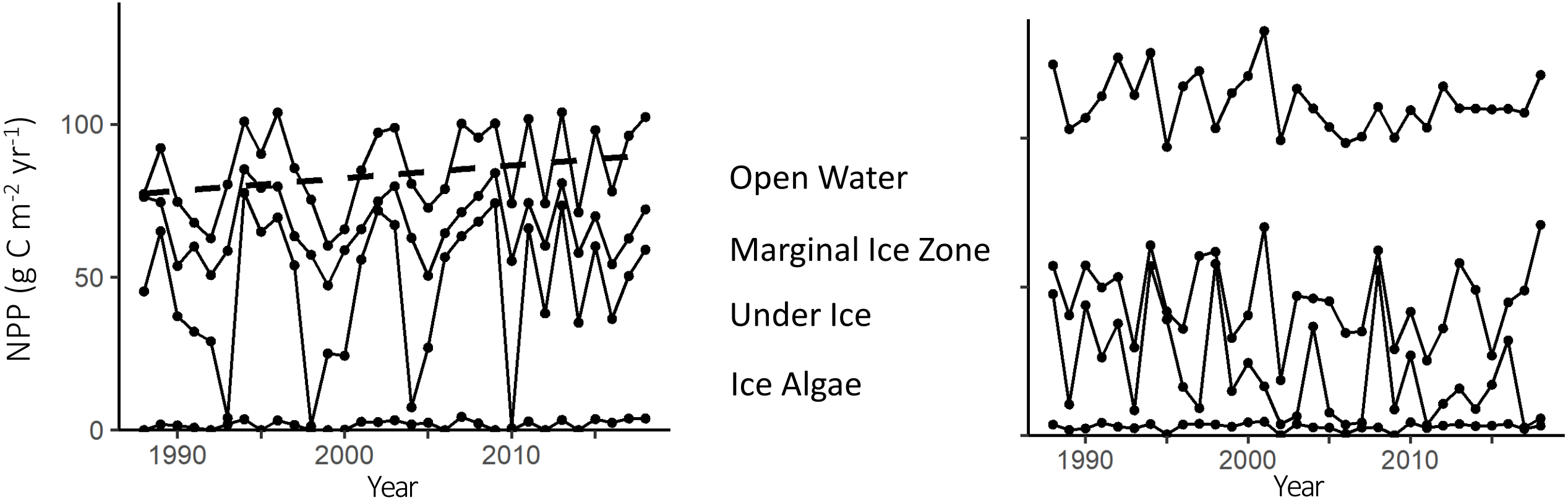
Under Ice

Ice Algae

High NPP during the open water period generated 22% more annual NPP in the south

North

South



Chukchi Sea

- UI blooms can generate half of total NPP in the northern Chukchi Sea. However, their contributions to NPP are diminishing in the southern Chukchi Sea.
- UI blooms are associated with lower zooplankton grazing.

Chukchi Sea

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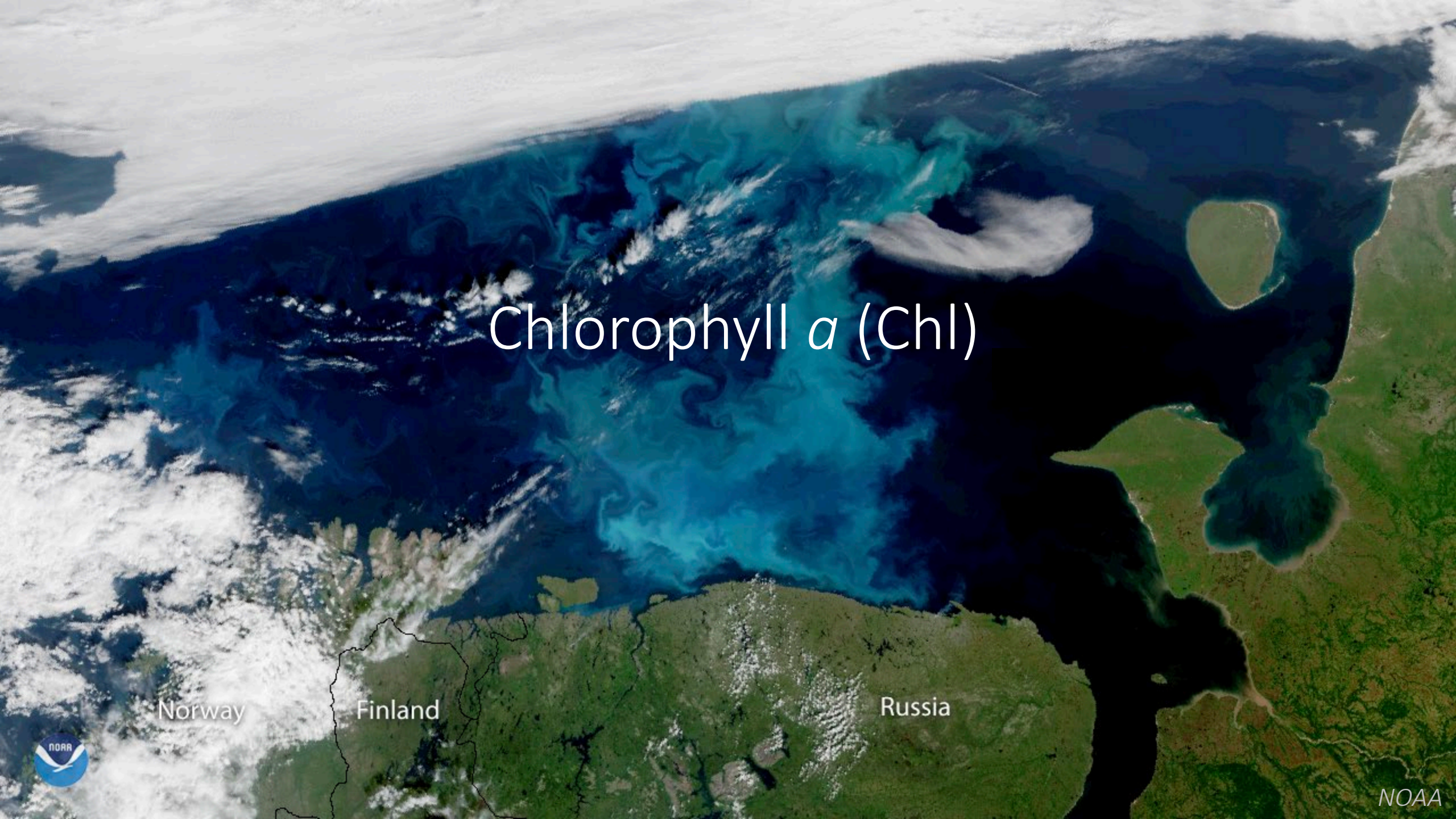
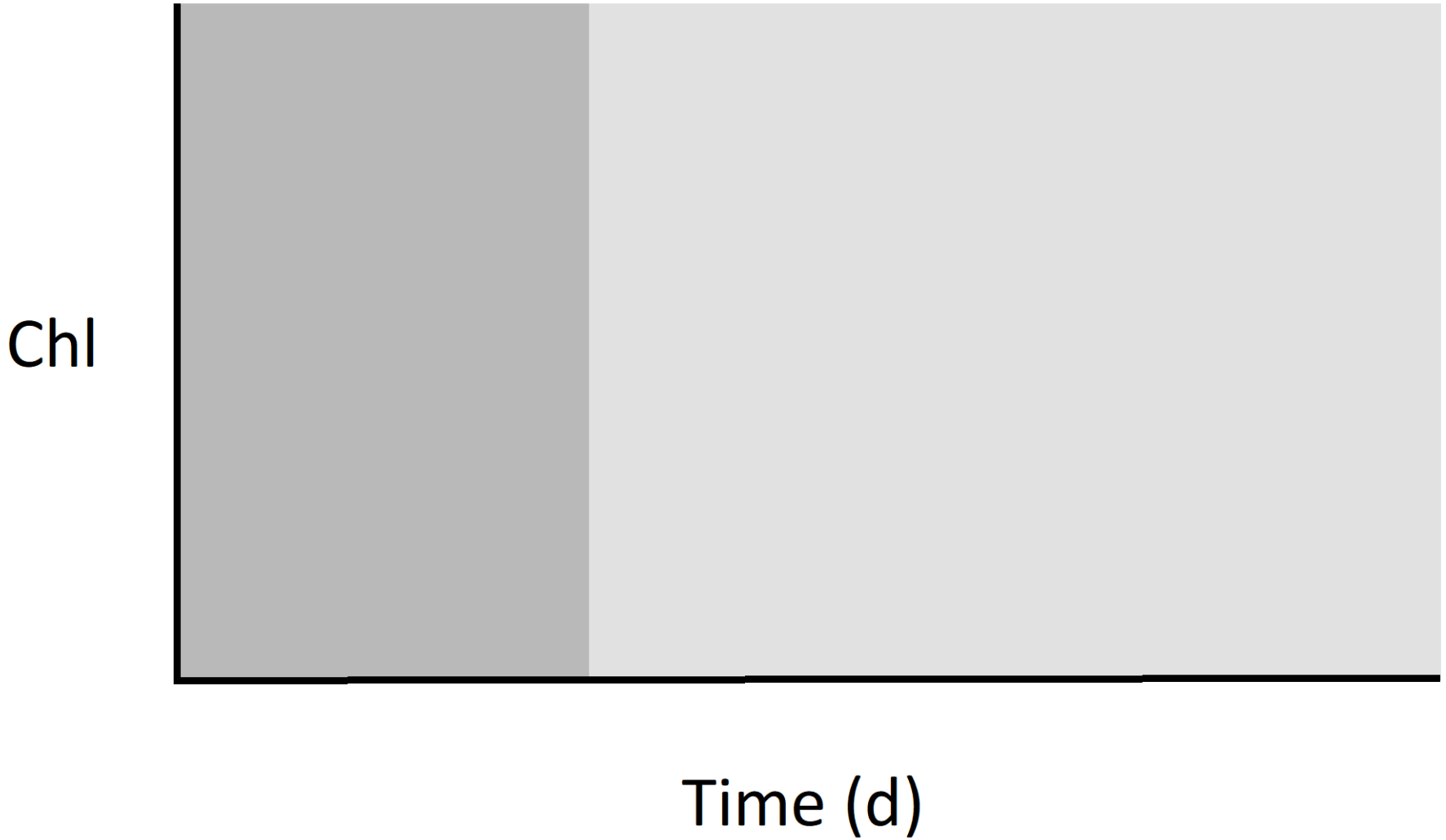
Arctic Ocean

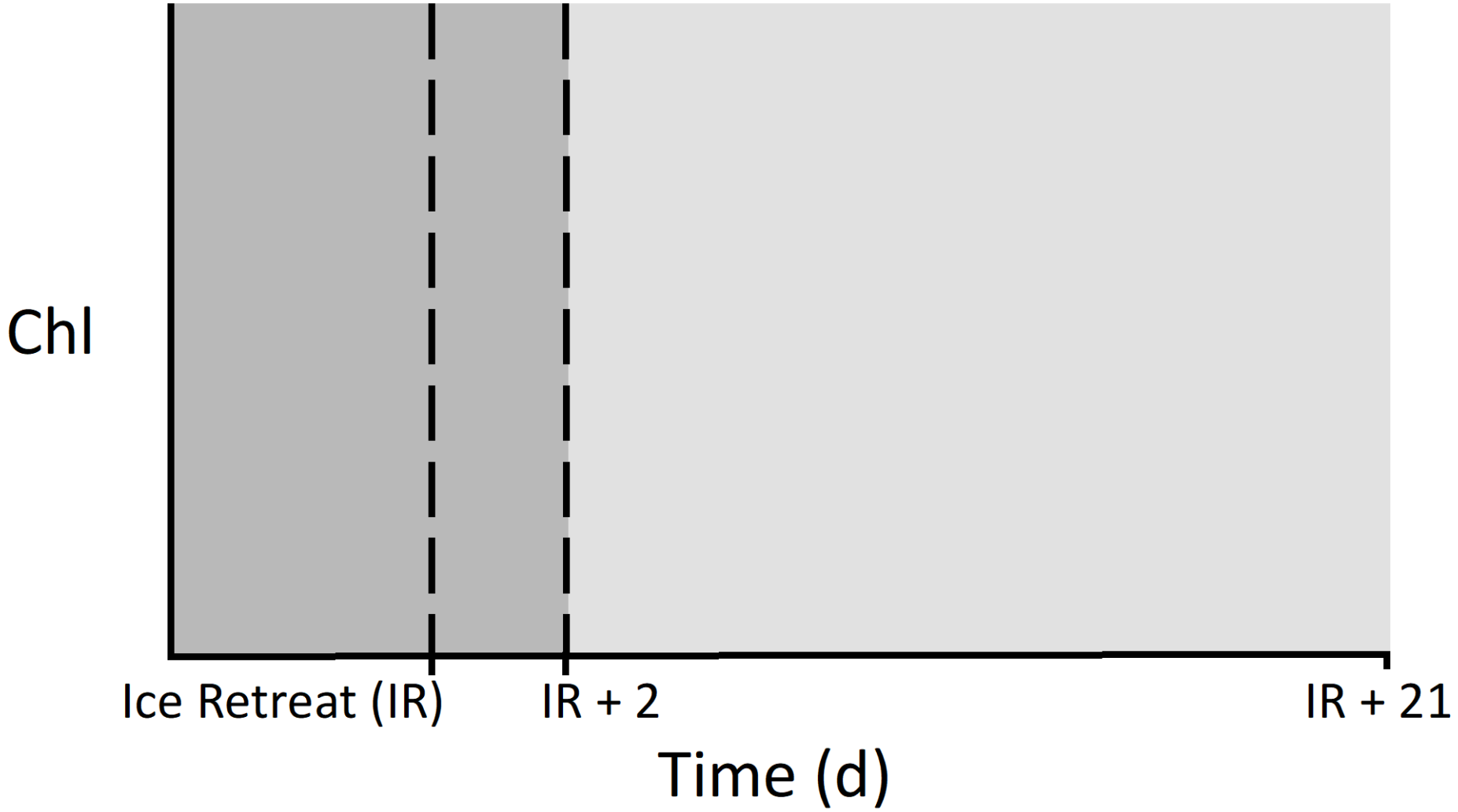
- What is the distribution of UI blooms across the Arctic Ocean, and how has this changed over time?


Chlorophyll *a* (Chl)
Norway
Finland
Russia
NOAA

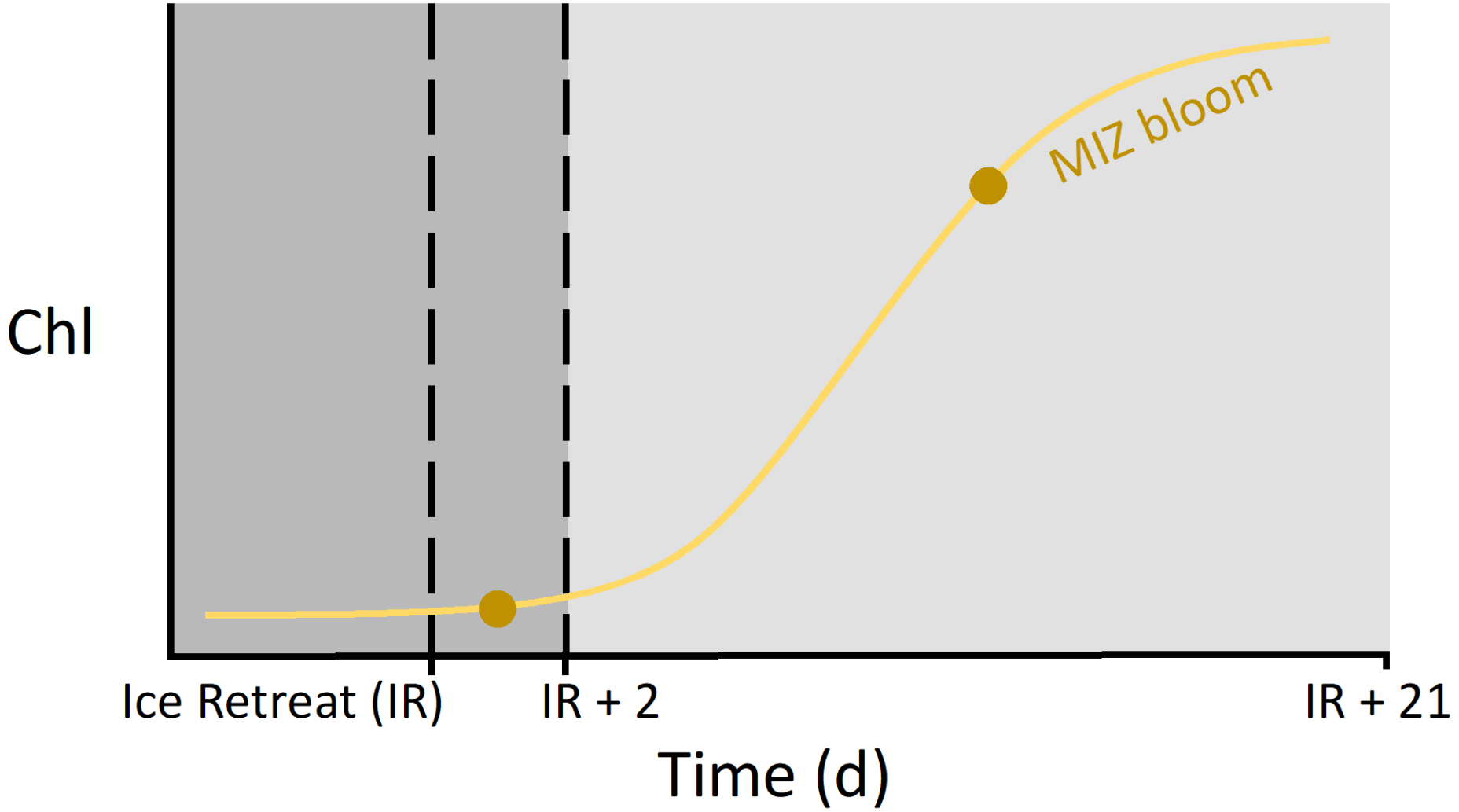
Using satellite Chl retrievals around the time of ice retreat to classify blooms



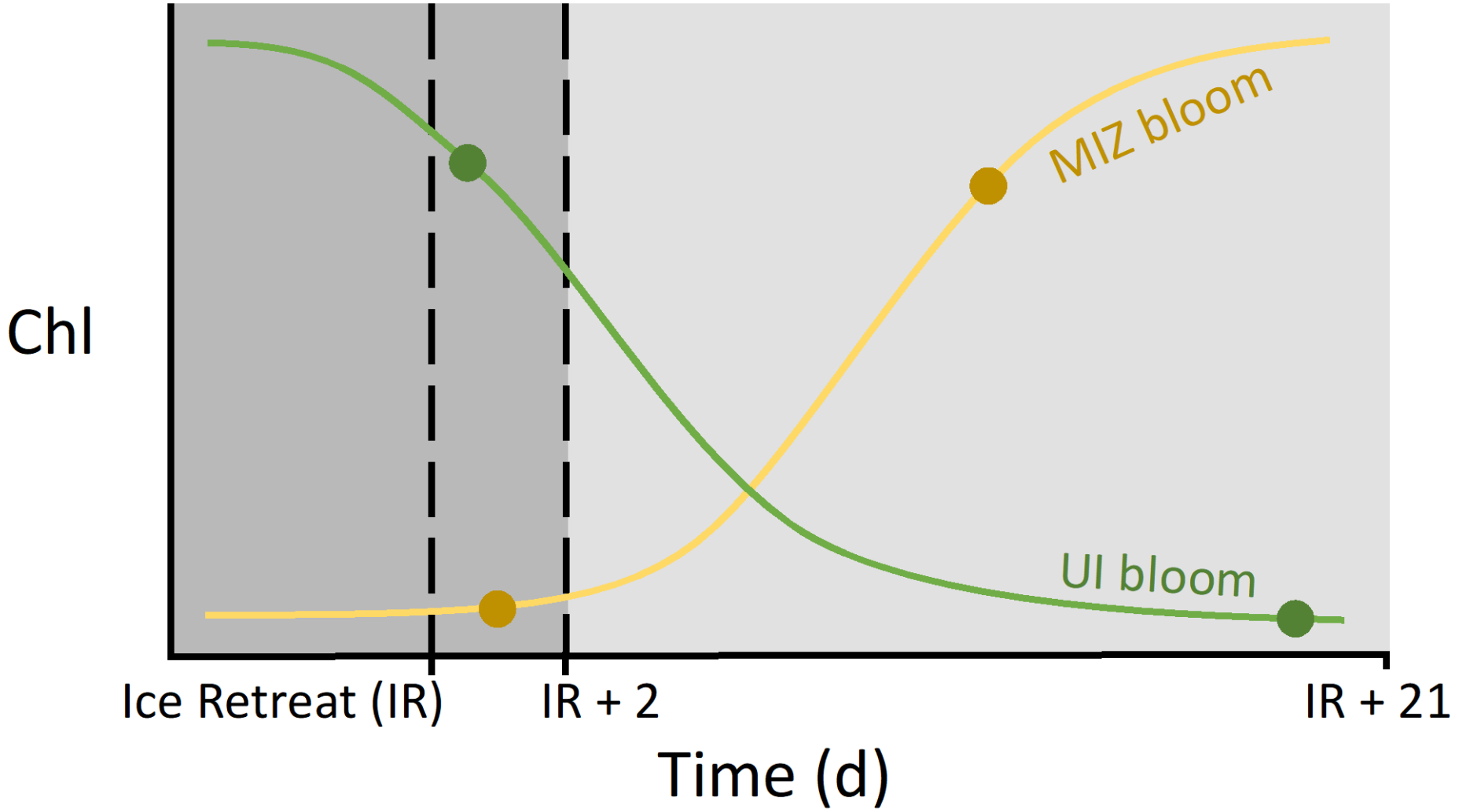
Using satellite Chl retrievals around the time of ice retreat to classify blooms



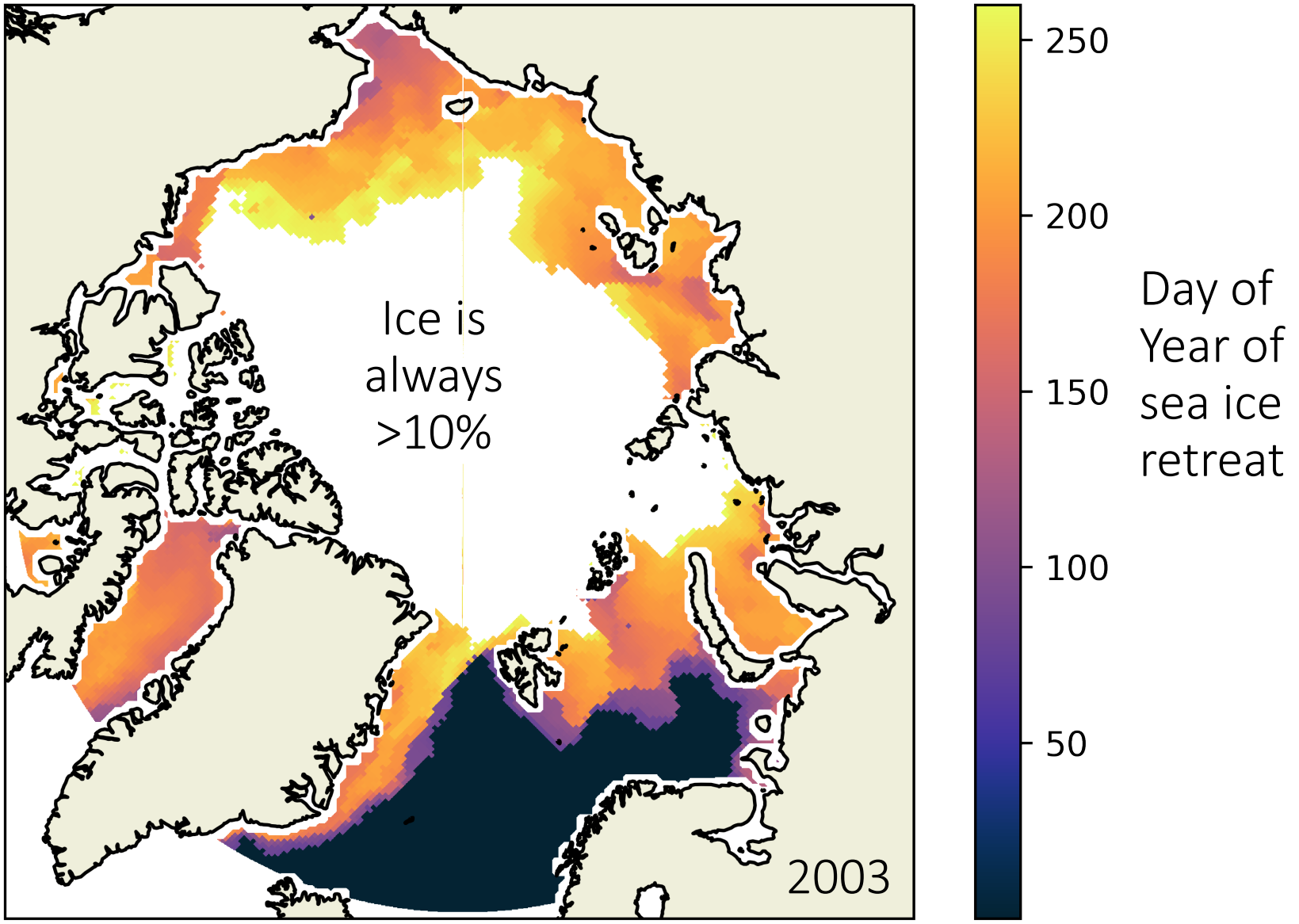
Using satellite Chl retrievals around the time of ice retreat to classify blooms



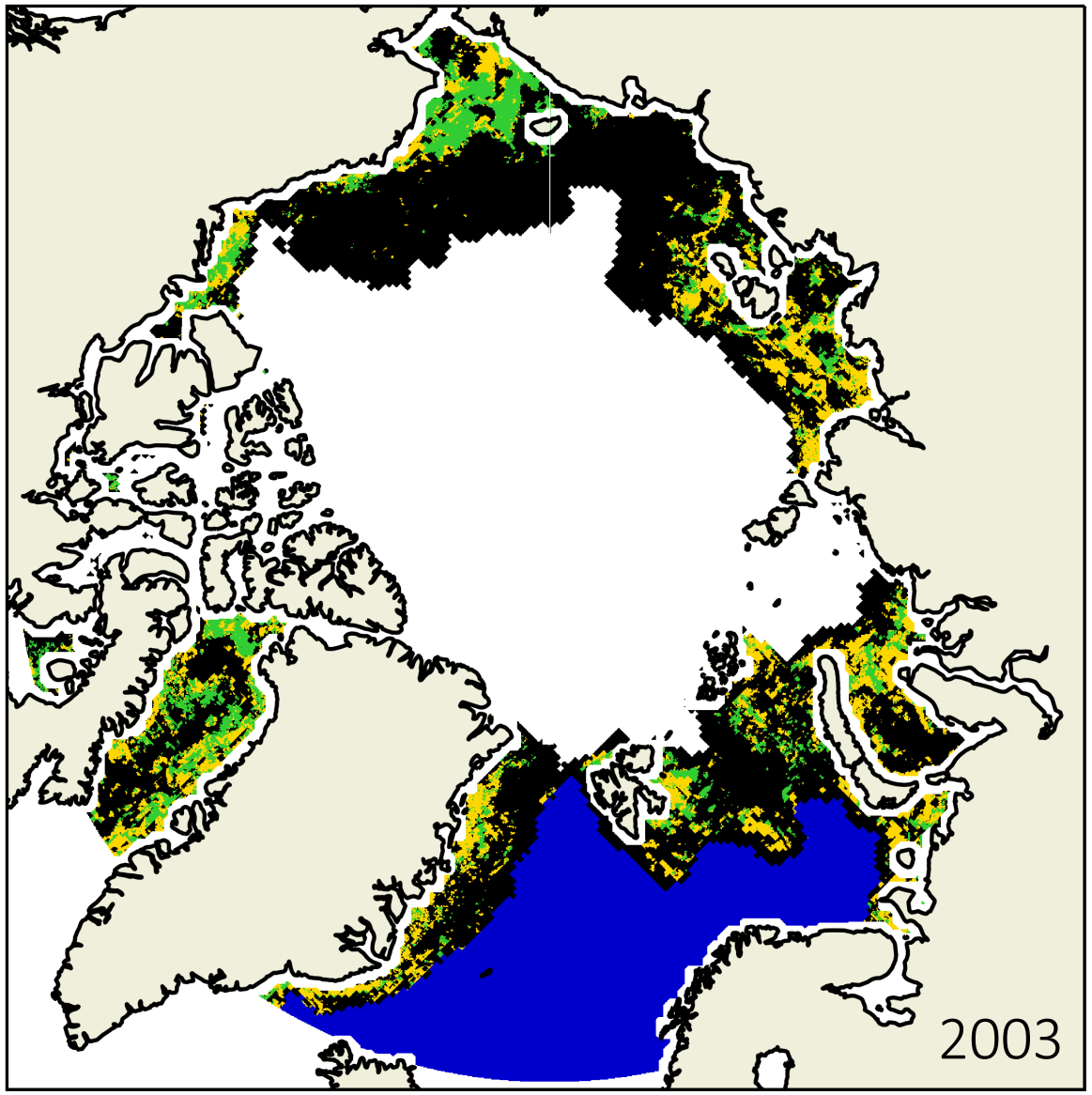
Using satellite Chl retrievals around the time of ice retreat to classify blooms



Ice retreat = falls to 10% sea ice cover



Classifying blooms



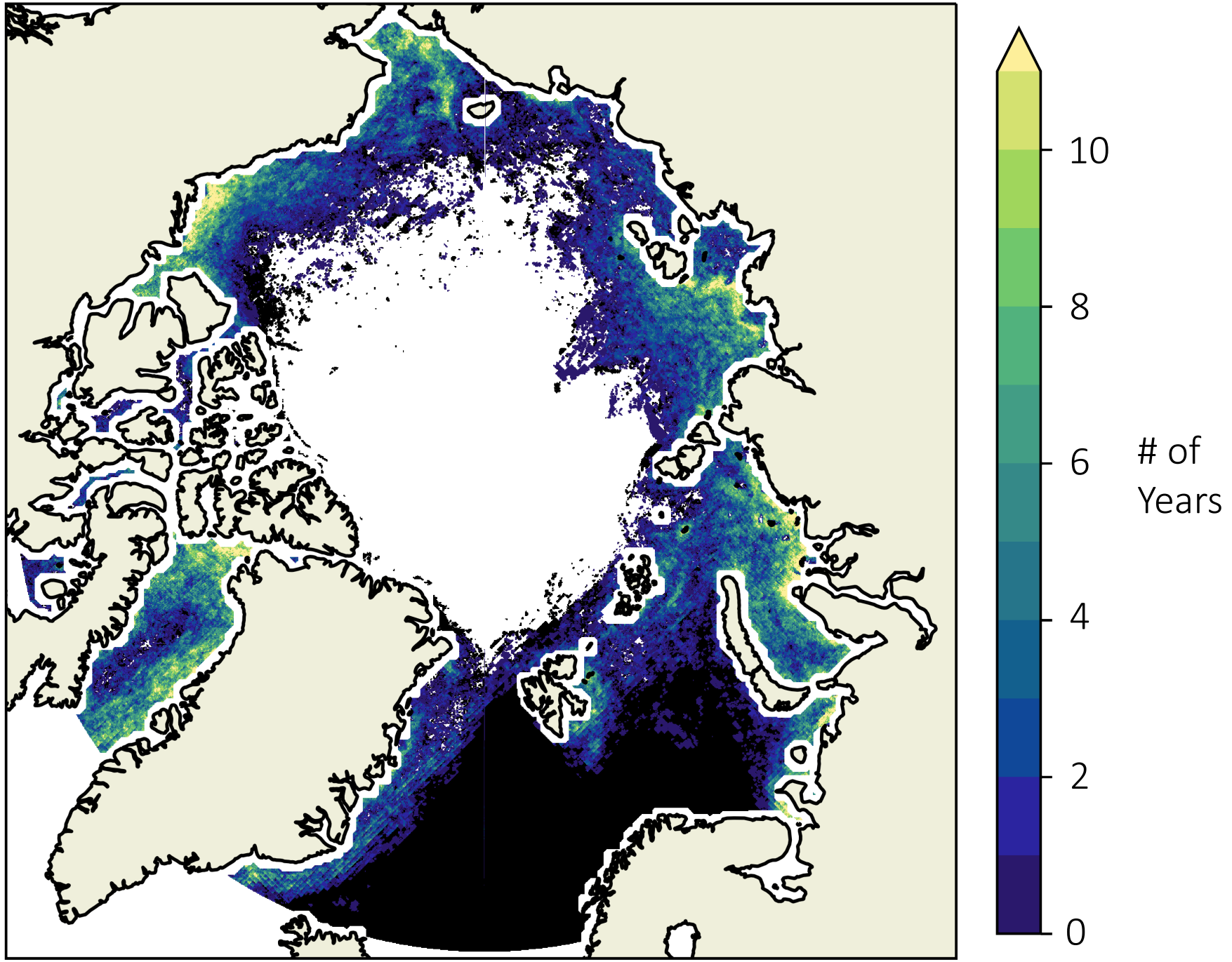
Under-Ice

Marginal Ice Zone

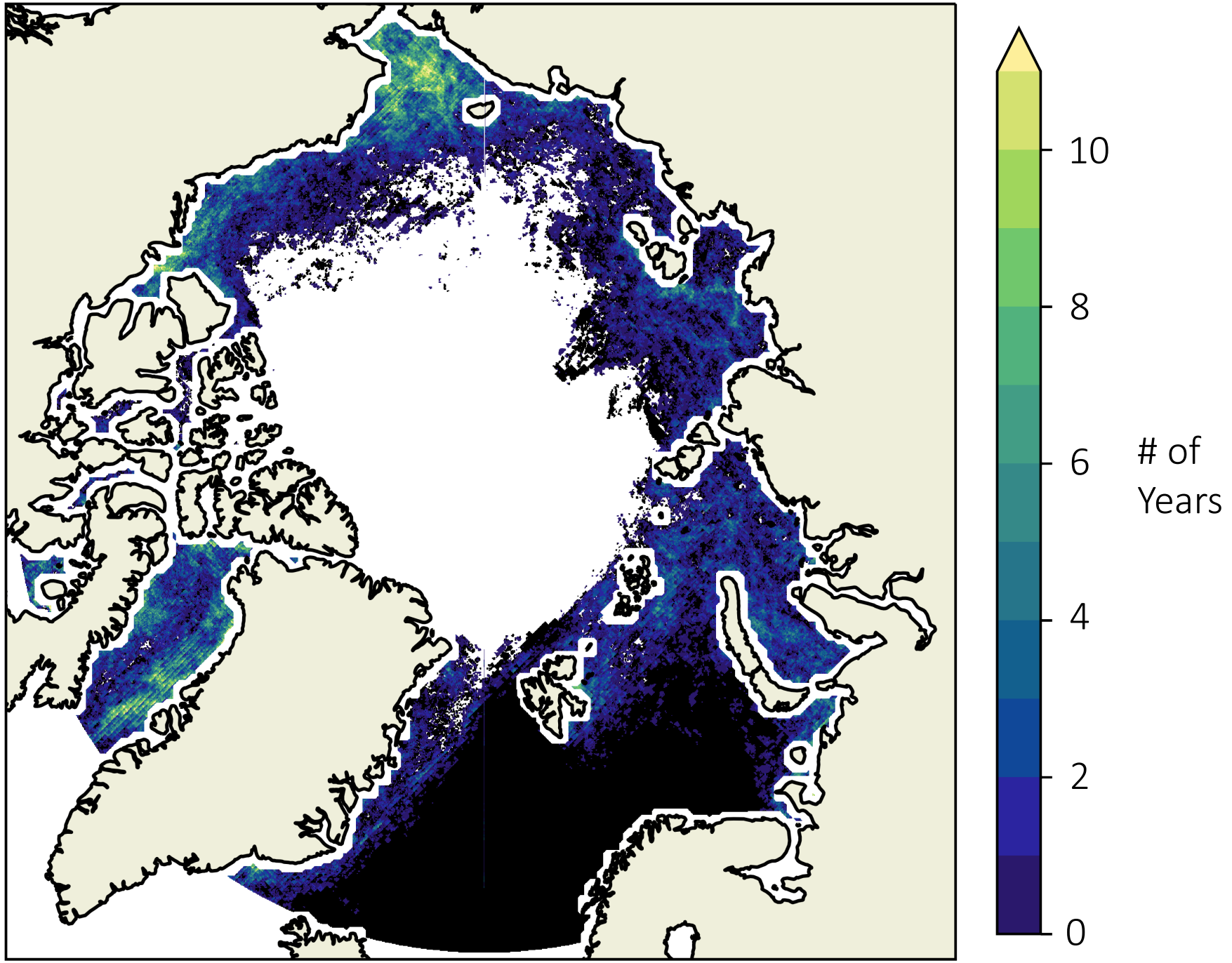
Insufficient Observations

Ice Free

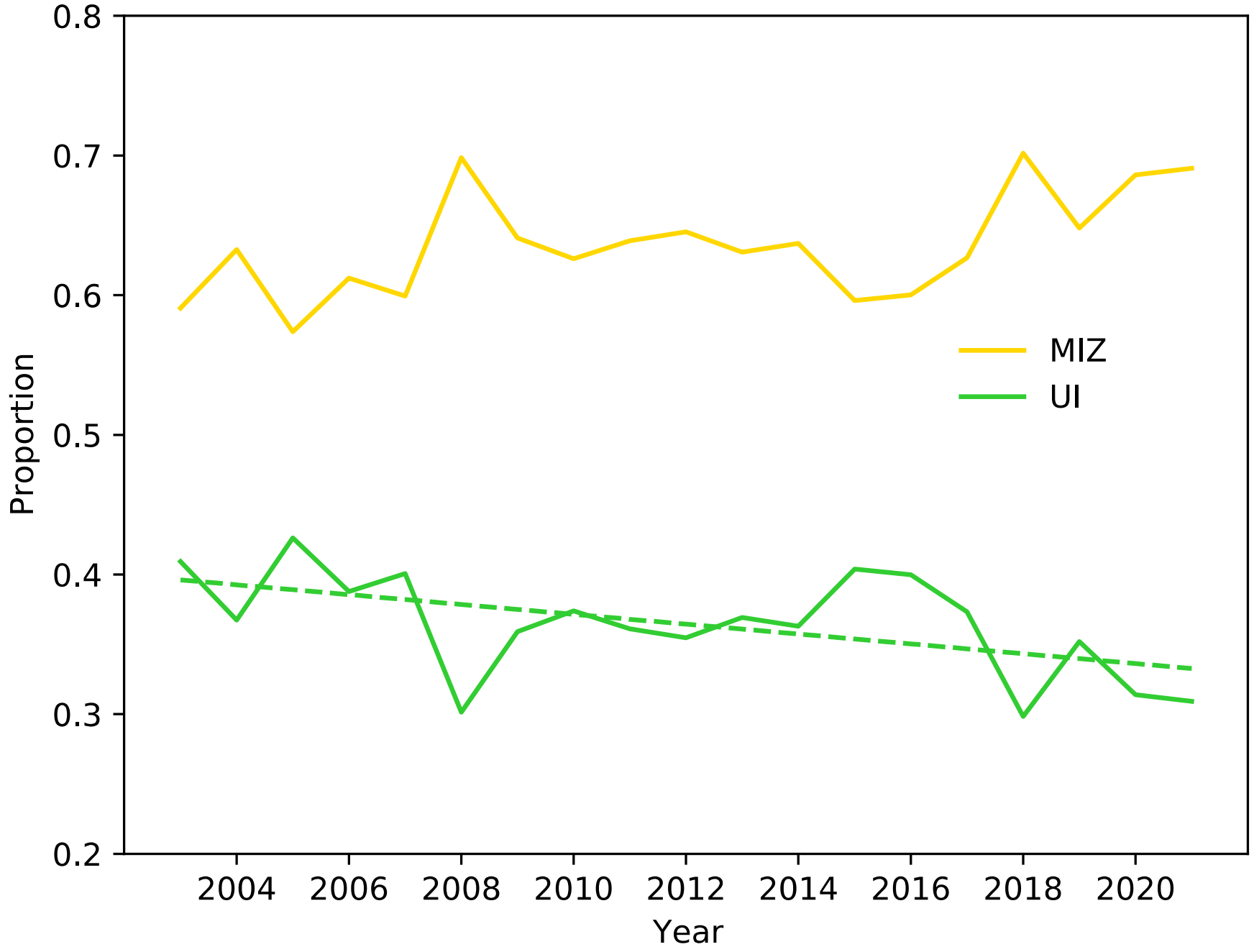
64% of the seasonally ice-free Arctic Ocean generated MIZ blooms



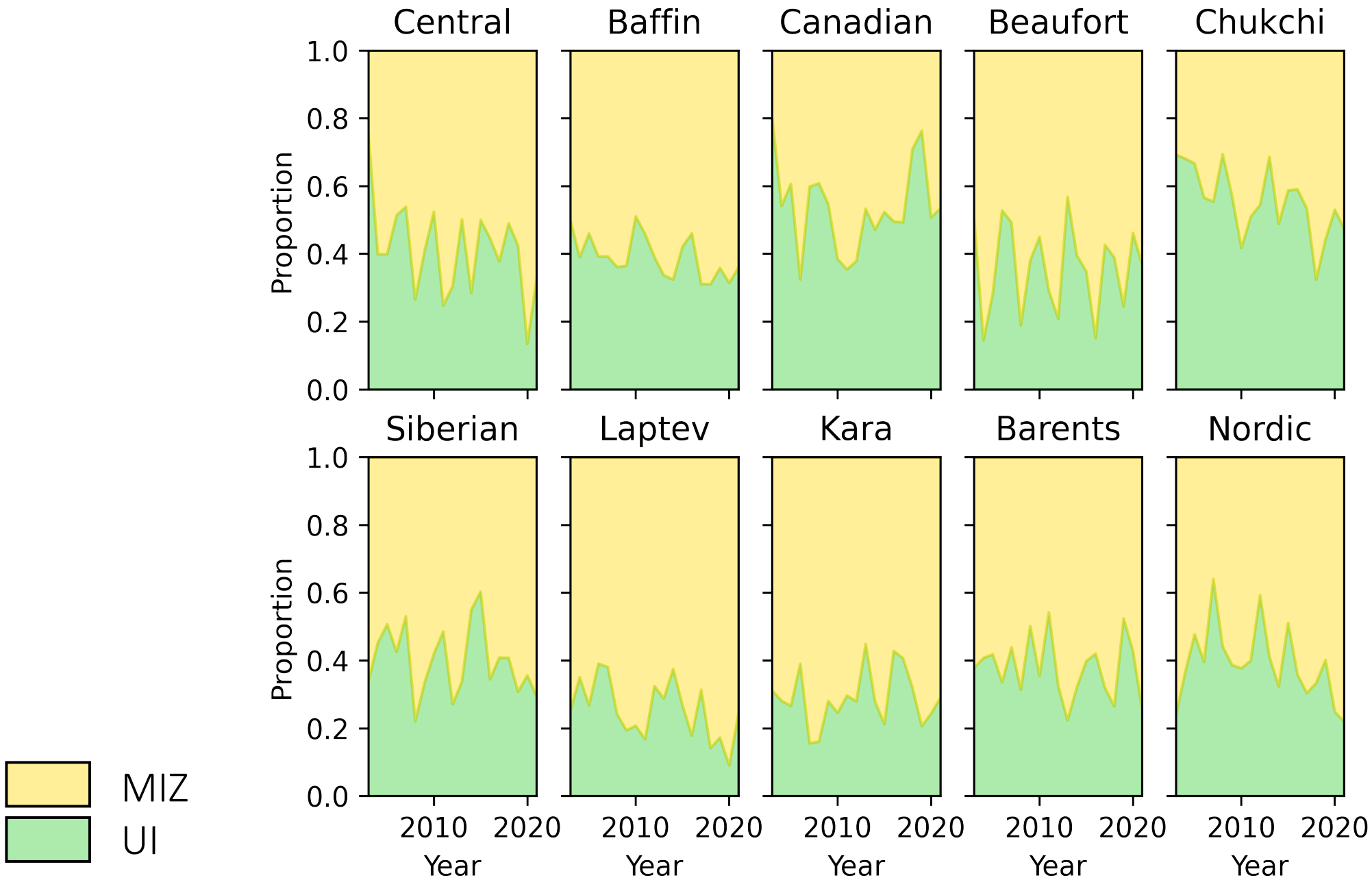
UI blooms covered 36% of the seasonally ice-free Arctic Ocean

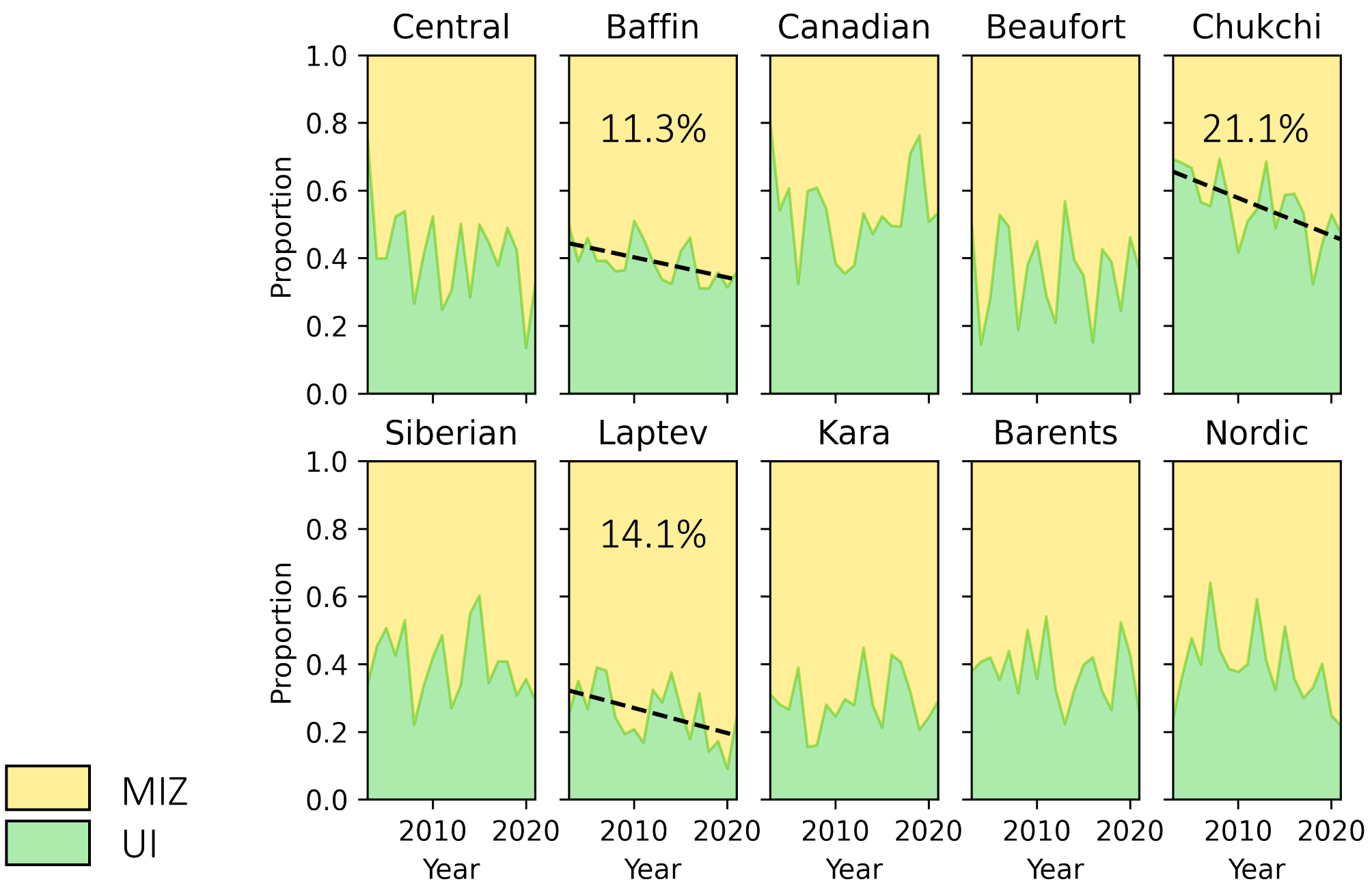


UI blooms declined as a proportion of total observable area




Beaufort
Chukchi
Siberian
Laptev
Central
Canadian
Kara
Baffin
Nordic
Barents

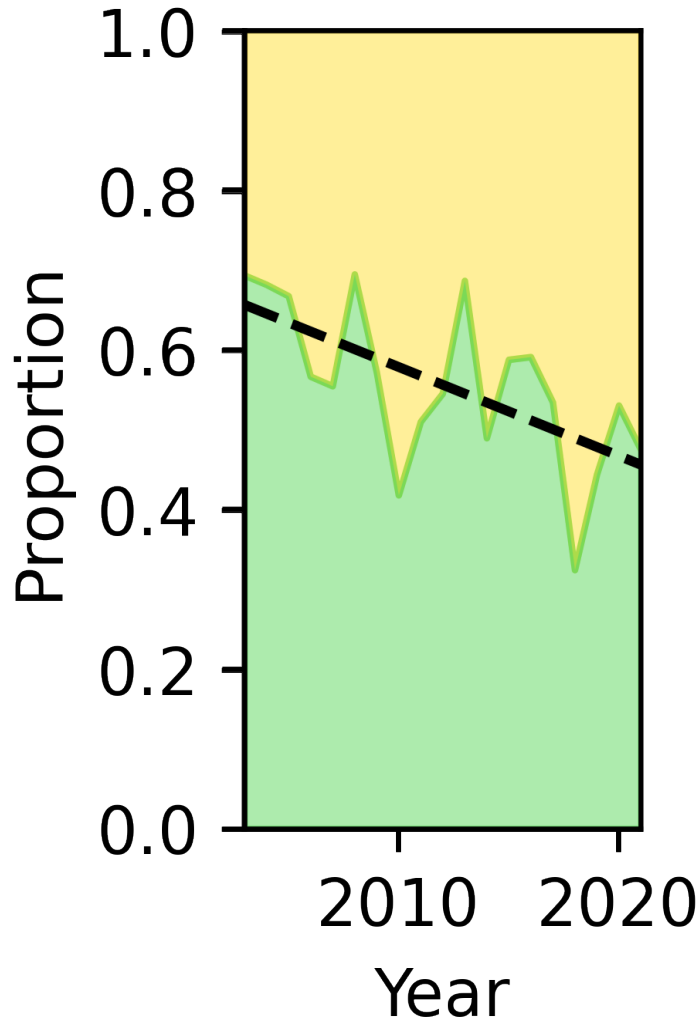

Central
Baffin
Canadian
Beaufort
Chukchi
Siberian
Laptev
Kara
Barents
Nordic
Proportion
1.0
0.8
0.6
0.4
0.2
0.0
2010
2020
Year
MIZ
UI


Central
Baffin
Canadian
Beaufort
Chukchi
Siberian
Laptev
Kara
Barents
Nordic
11.3%
21.1%
14.1%
Proportion
1.0
0.8
0.6
0.4
0.2
0.0
2010
2020
Year
MIZ
UI

Chukchi Sea

- UI blooms are the most prevalent in the Chukchi Sea
  - 56% of observable area
  - 100,000 km^2
- UI blooms are also declining most rapidly in the Chukchi Sea
  - 2003: 130,000 km^2
  - 2021: 66,000 km^2

  } Nearly 50% decline
- Lower latitudes (66.5-70°N) drove the decline in UI blooms.



Chukchi Sea

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Arctic Ocean

- UI blooms are likely generated across 40% of the sea ice-covered Arctic Ocean.

Chukchi Sea

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Chukchi Sea

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- UI blooms are associated with lower zooplankton grazing.

Arctic Ocean

- UI blooms are likely generated across 40% of the sea ice-covered Arctic Ocean. UI blooms are most prevalent in the Chukchi Sea, but the Chukchi also drives their decline in prevalence across the Arctic.

Implications

- UI blooms are widespread and can substantially contribute to total annual NPP
- These blooms are important for determining food availability and biogeochemical cycles
- UI blooms are likely declining across the Arctic, driven by declines in coverage in the Chukchi Sea


Thank you
Stefan Hendricks