Quantifying under-ice phytoplankton primary production in the changing Arctic and Southern Oceans

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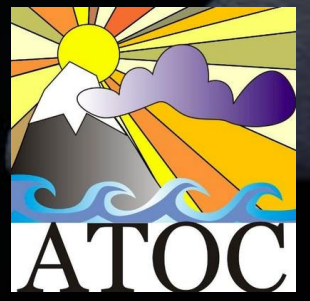
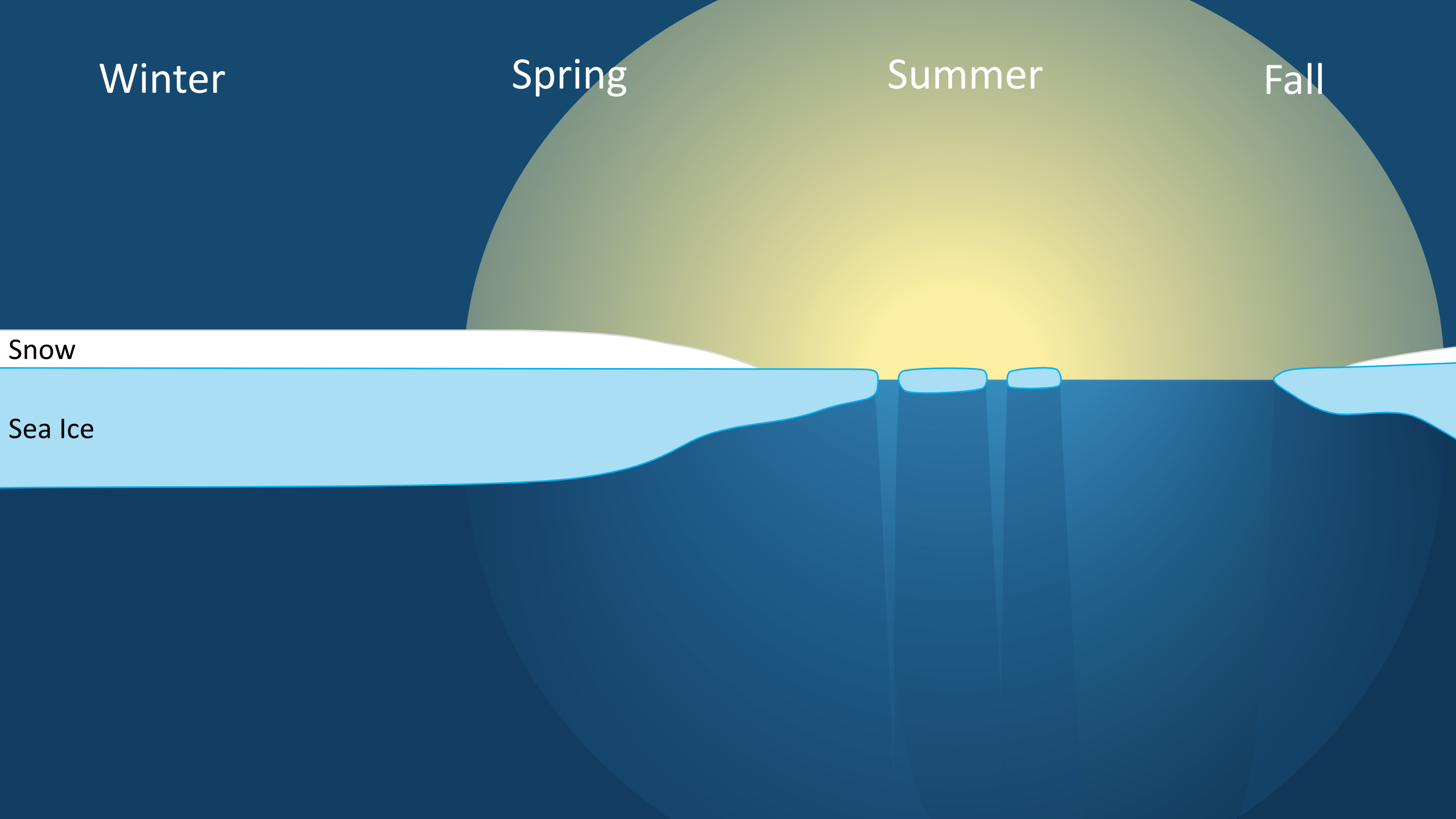
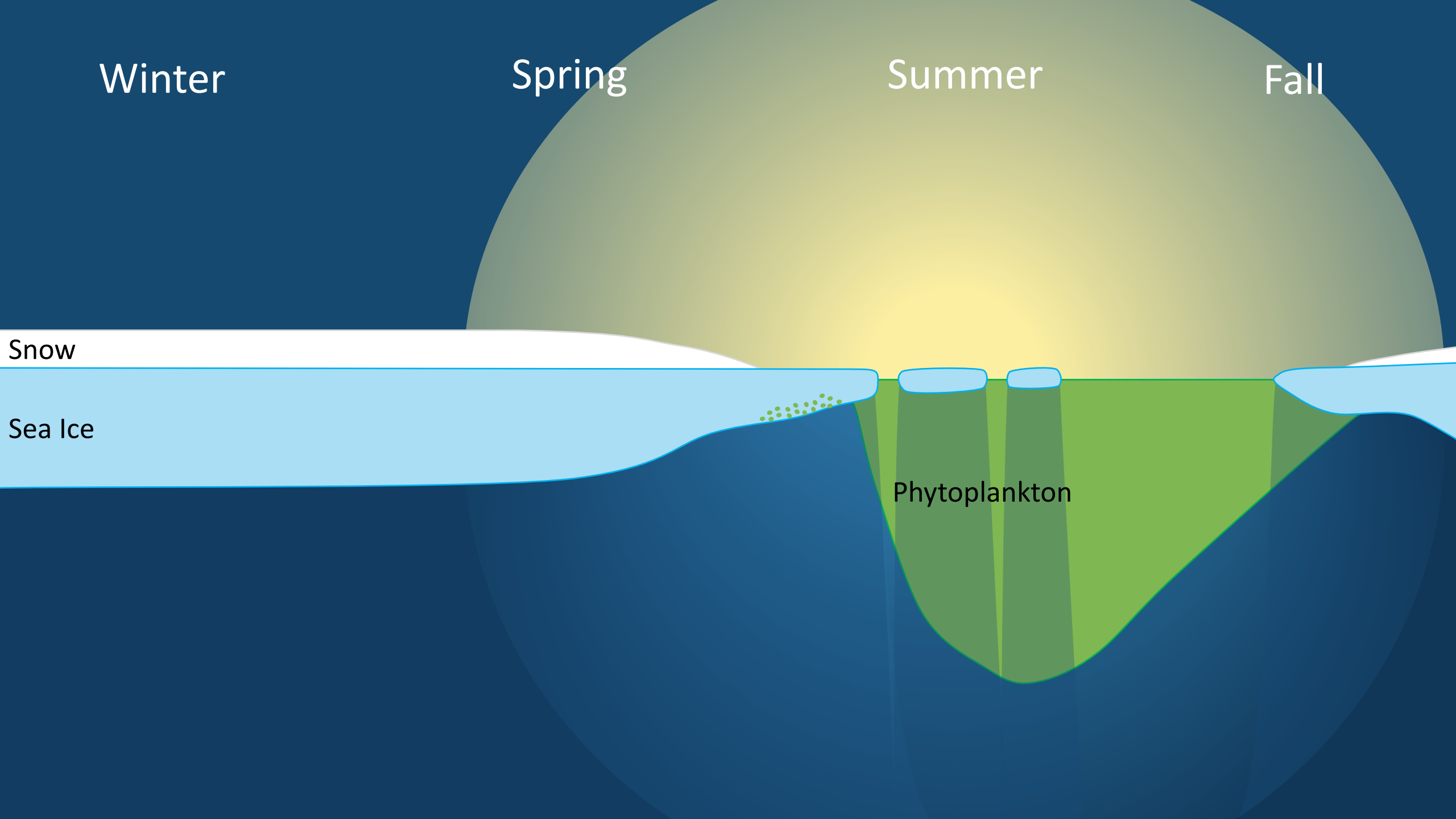
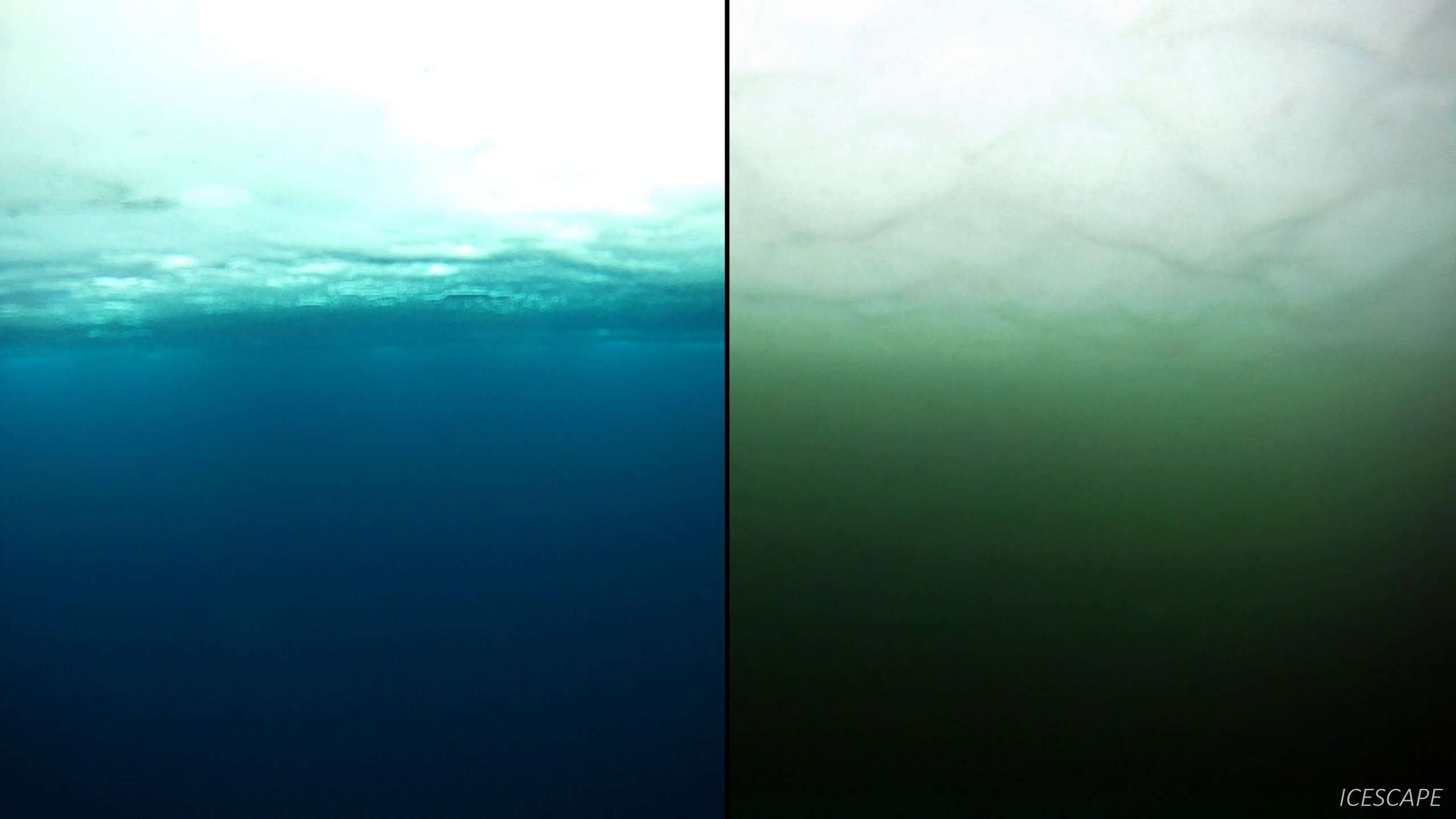
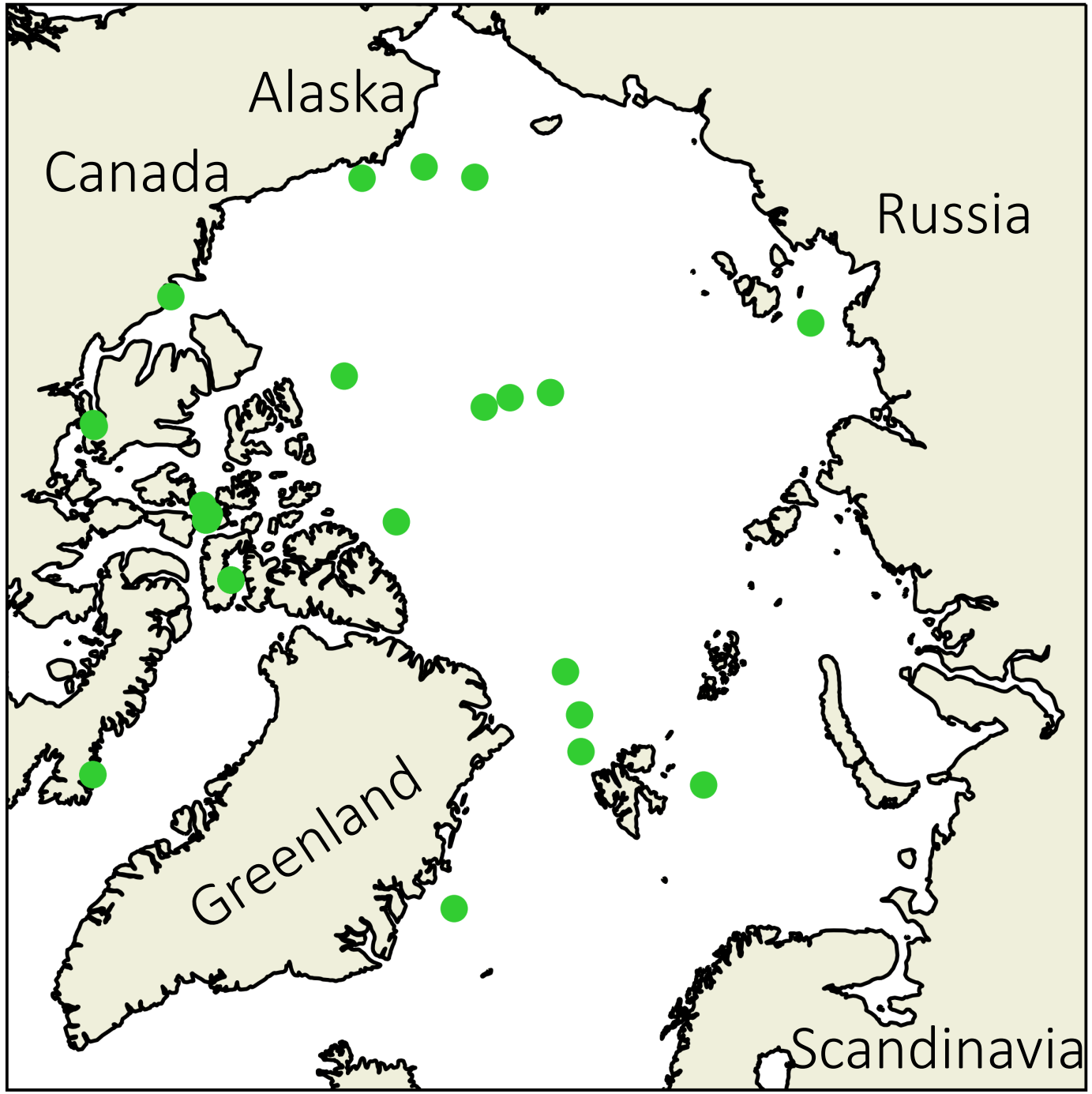


Kathryn Hansen

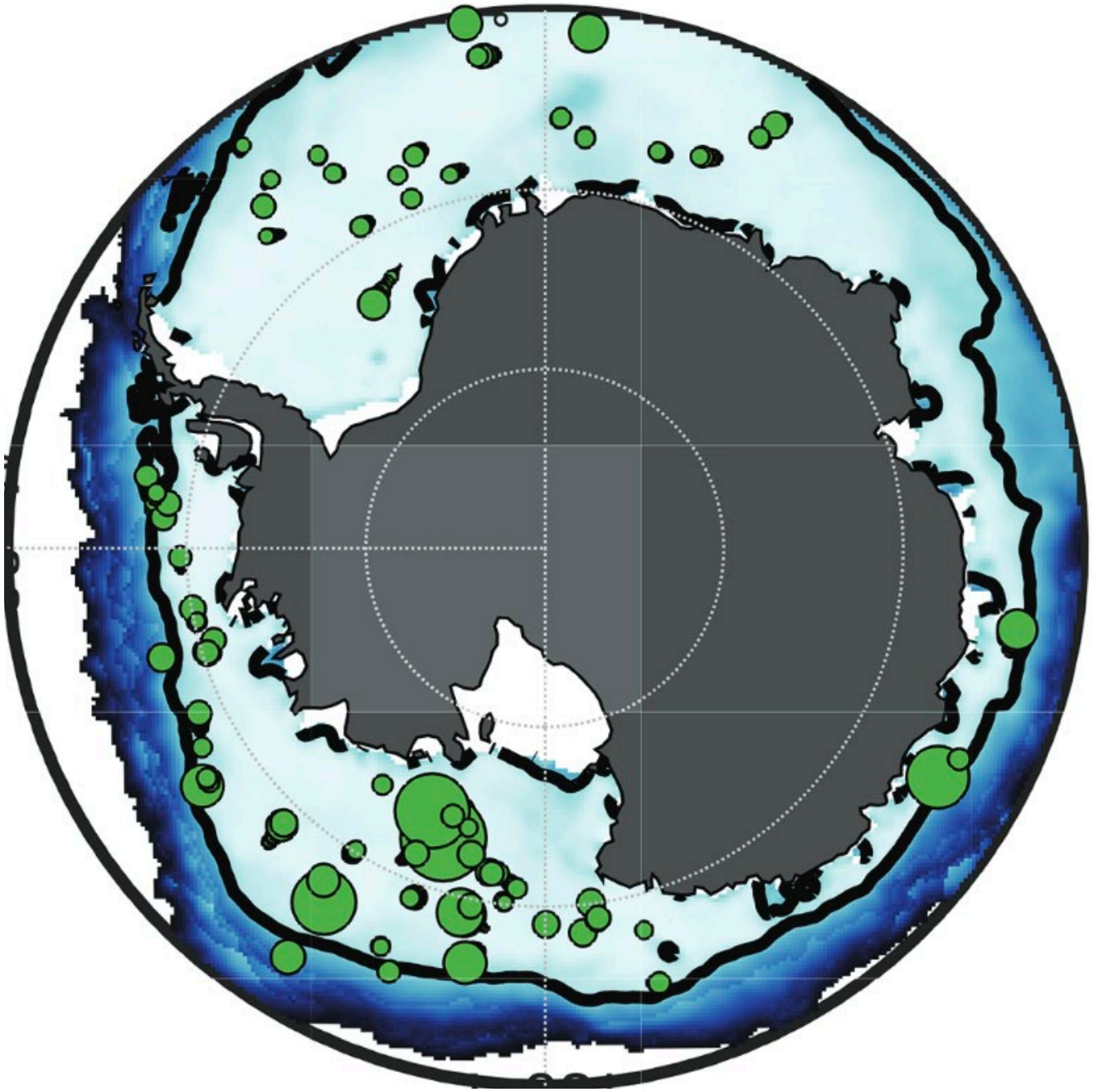

Winter
Spring
Summer
Fall
Snow
Sea Ice


Winter
Spring
Summer
Fall
Snow
Sea Ice
Phytoplankton


ICESCAPE



data from
Ardyna et al., 2020



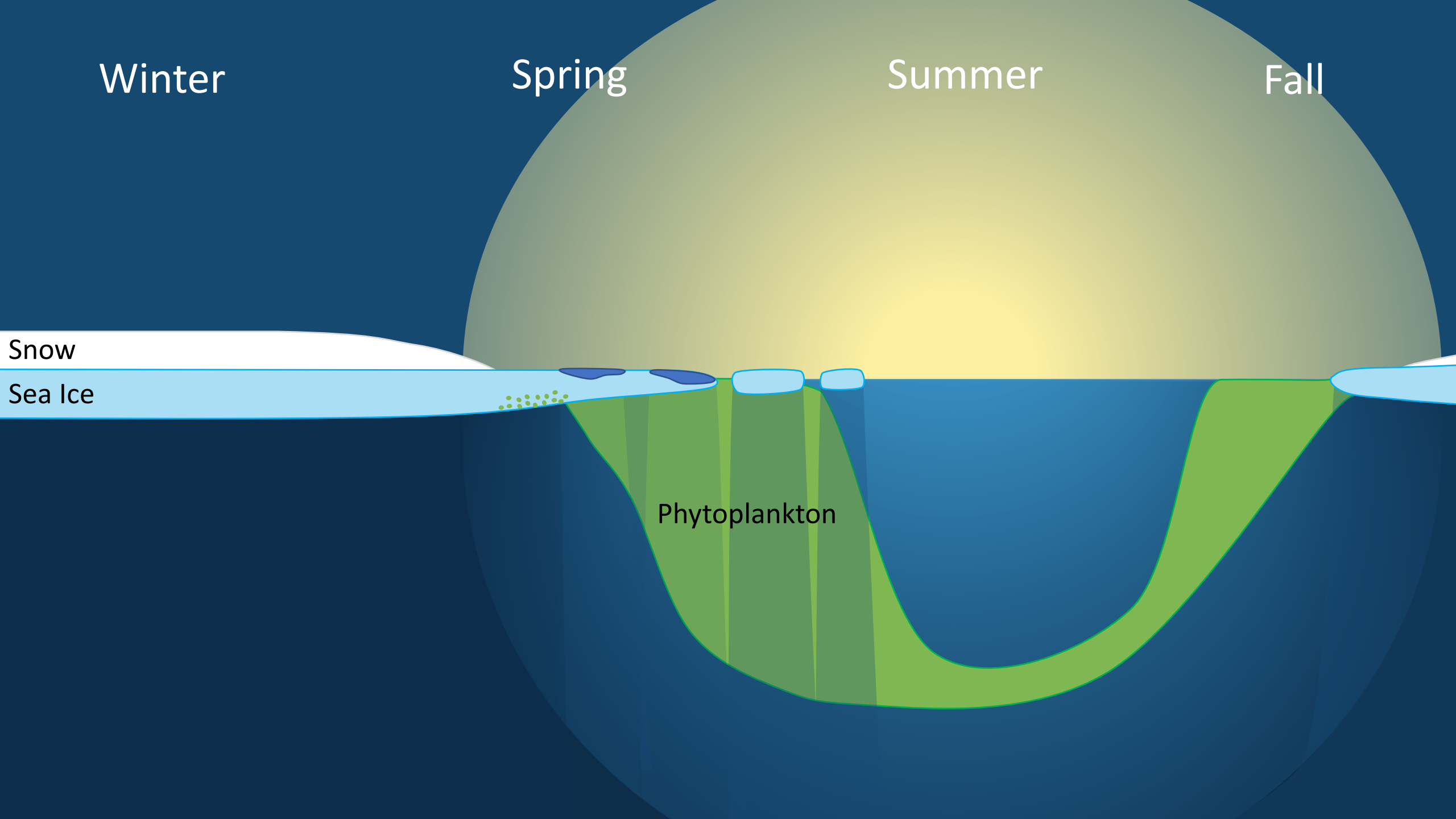
Sea Ice Concentration (%)

0 20 40 60 80 100

Phytoplankton Biomass

1 mg/m^3 3 mg/m^3

Horvat et al., 2022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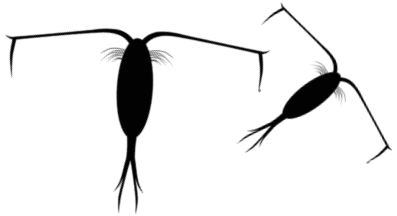
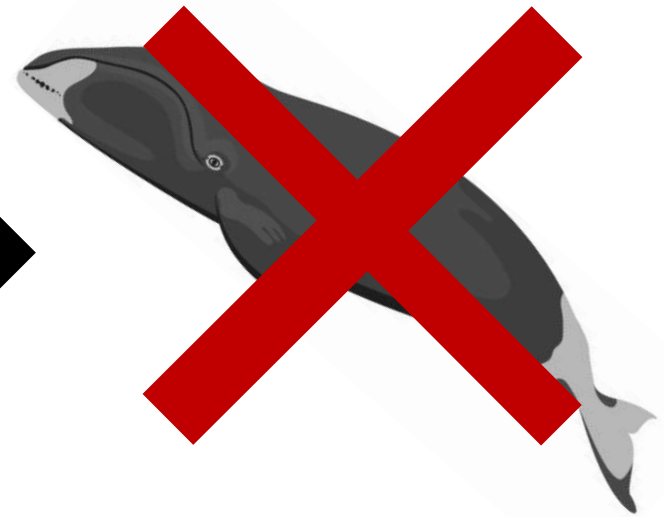
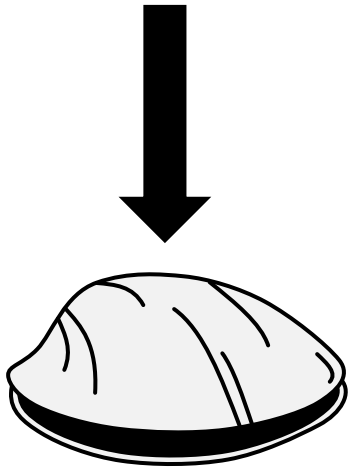
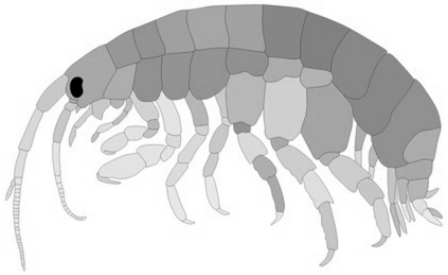
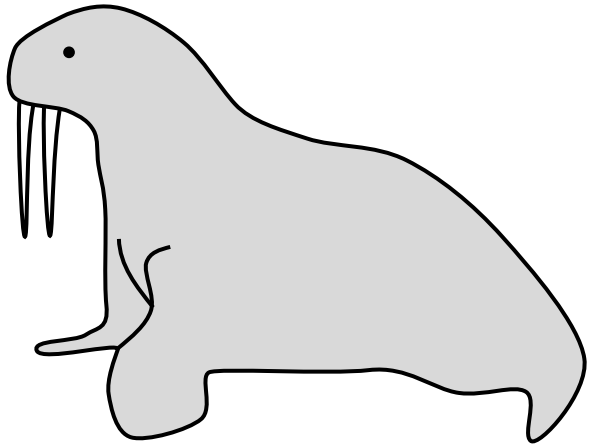










+ Carbon sequestration

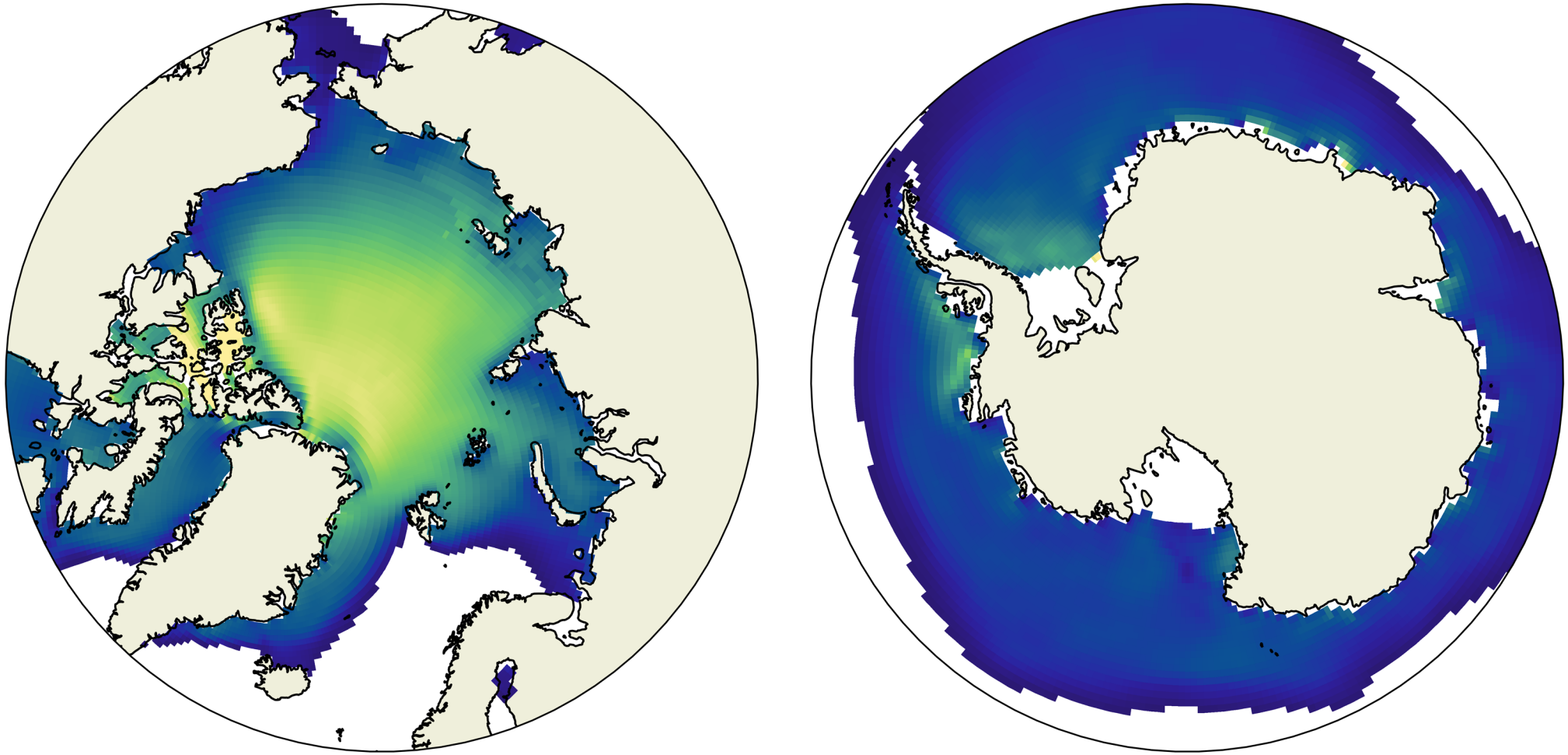
Under-ice (UI) phytoplankton net primary production (NPP)

- How much phytoplankton NPP is generated under sea ice in the Arctic and Southern Oceans?
- How is UI NPP changing over time (amount, spatial distribution)?
- Under what sea ice conditions (concentration, thickness) do UI blooms form in each region?

Special Community Earth System Model run

- CESM version 2, ‘less melt’ parameterized run
  - 4 phytoplankton and 2 zooplankton functional types
  - Daily output of light at the ocean surface and fractional coverage by each sea ice thickness category
- Calculated hourly light limitation terms under each sea ice thickness category and in open water.
- Partitioned daily NPP based on light limitation terms and area of each sea ice thickness category within each grid cell.

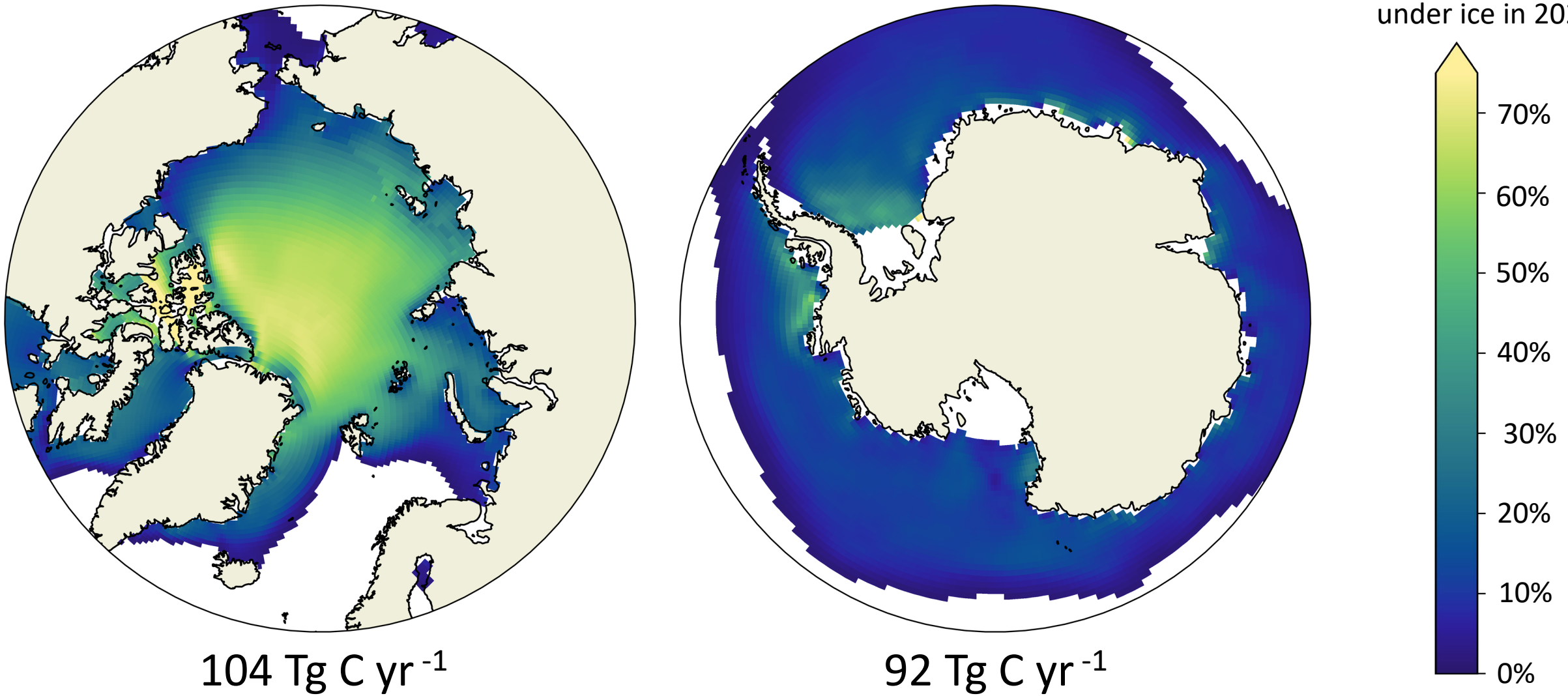
How much UI NPP is generated in the Arctic and Southern Oceans?



Proportion of total NPP generated under ice in 2020s

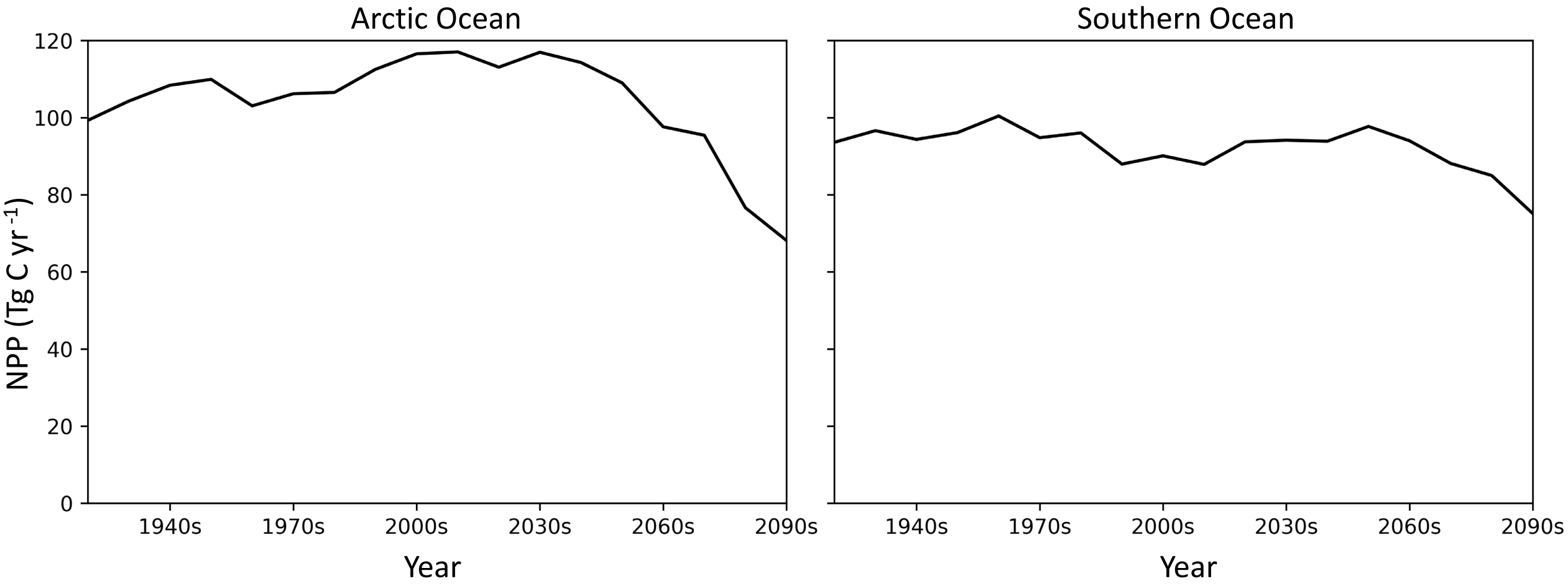
70%
60%
50%
40%
30%
20%
10%
0%

~100 Tg C yr^{-1} of NPP is generated under sea ice in each hemisphere

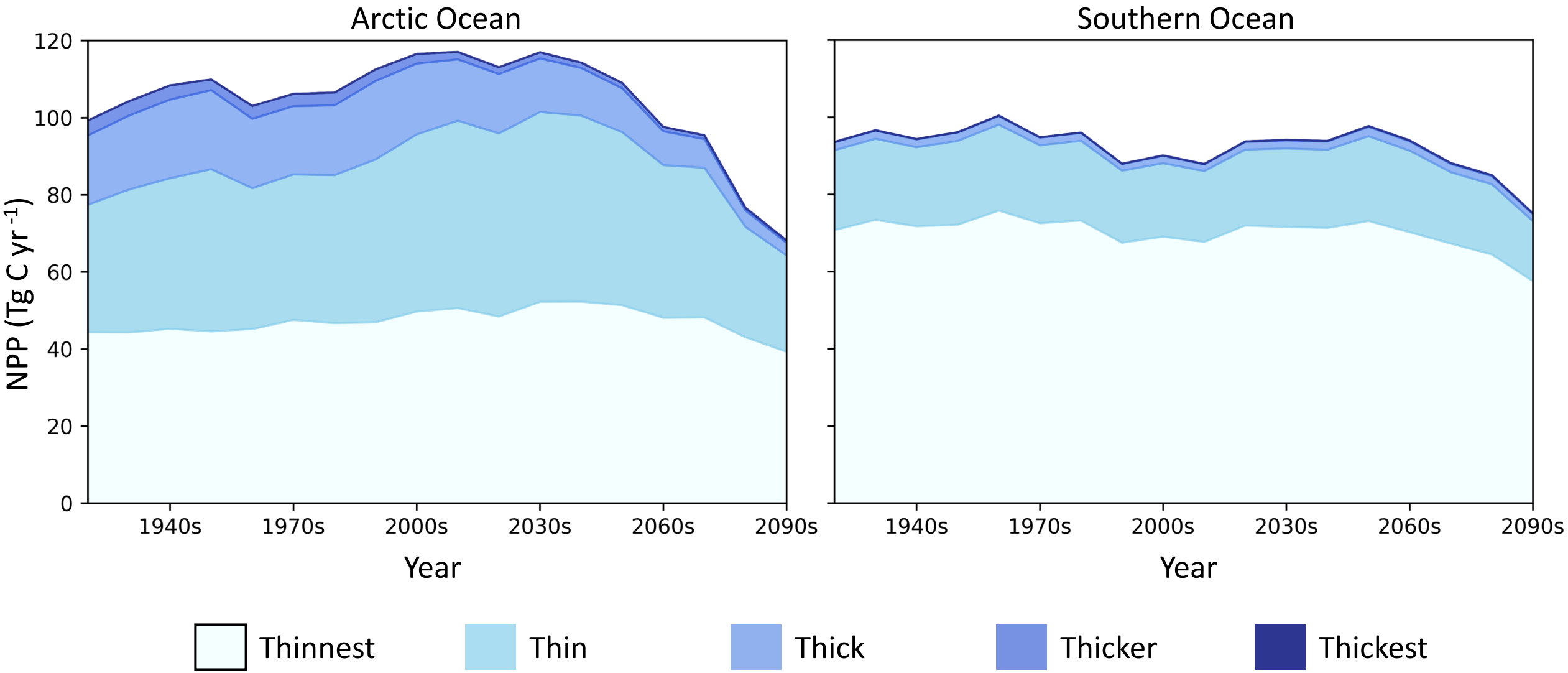


How is UI NPP changing over time?

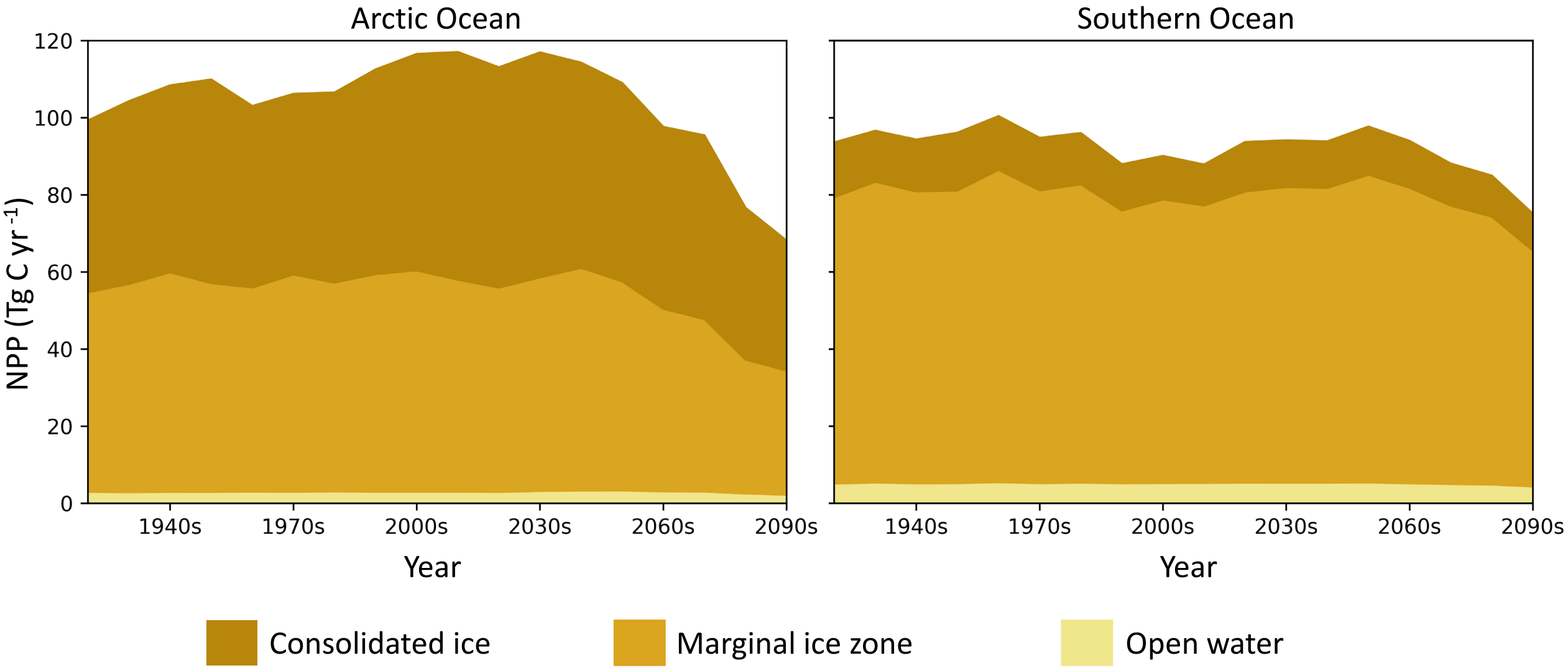
UI NPP will decline in both hemispheres



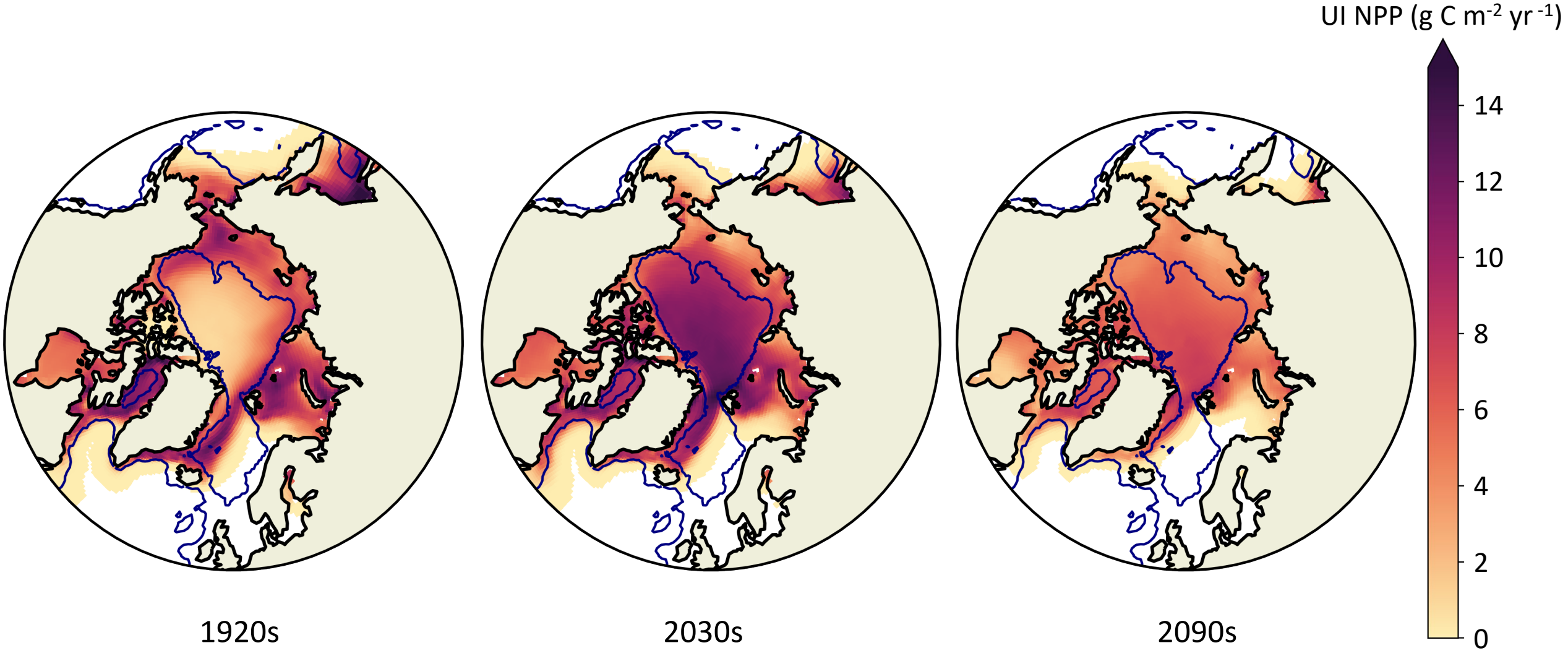
What sea ice thickness allows for UI NPP?



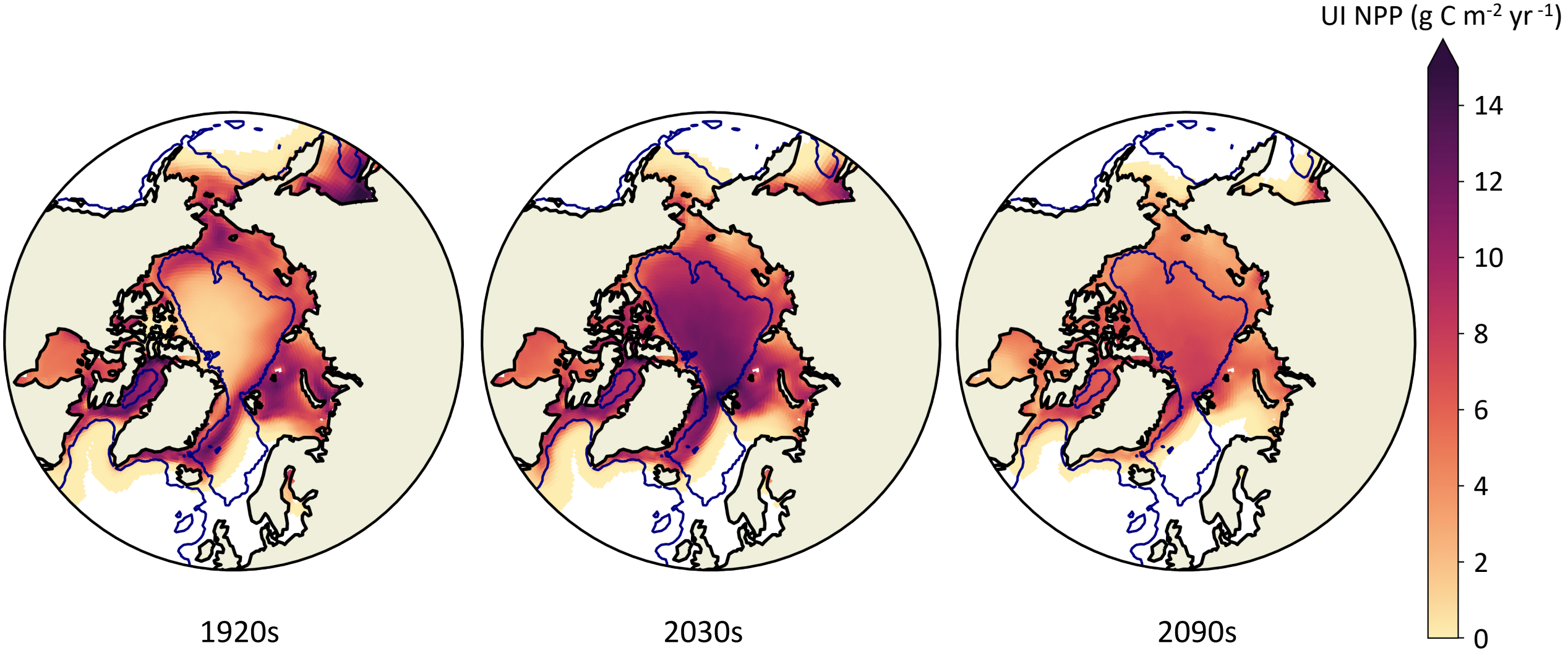
What sea ice concentration allows for UI NPP?



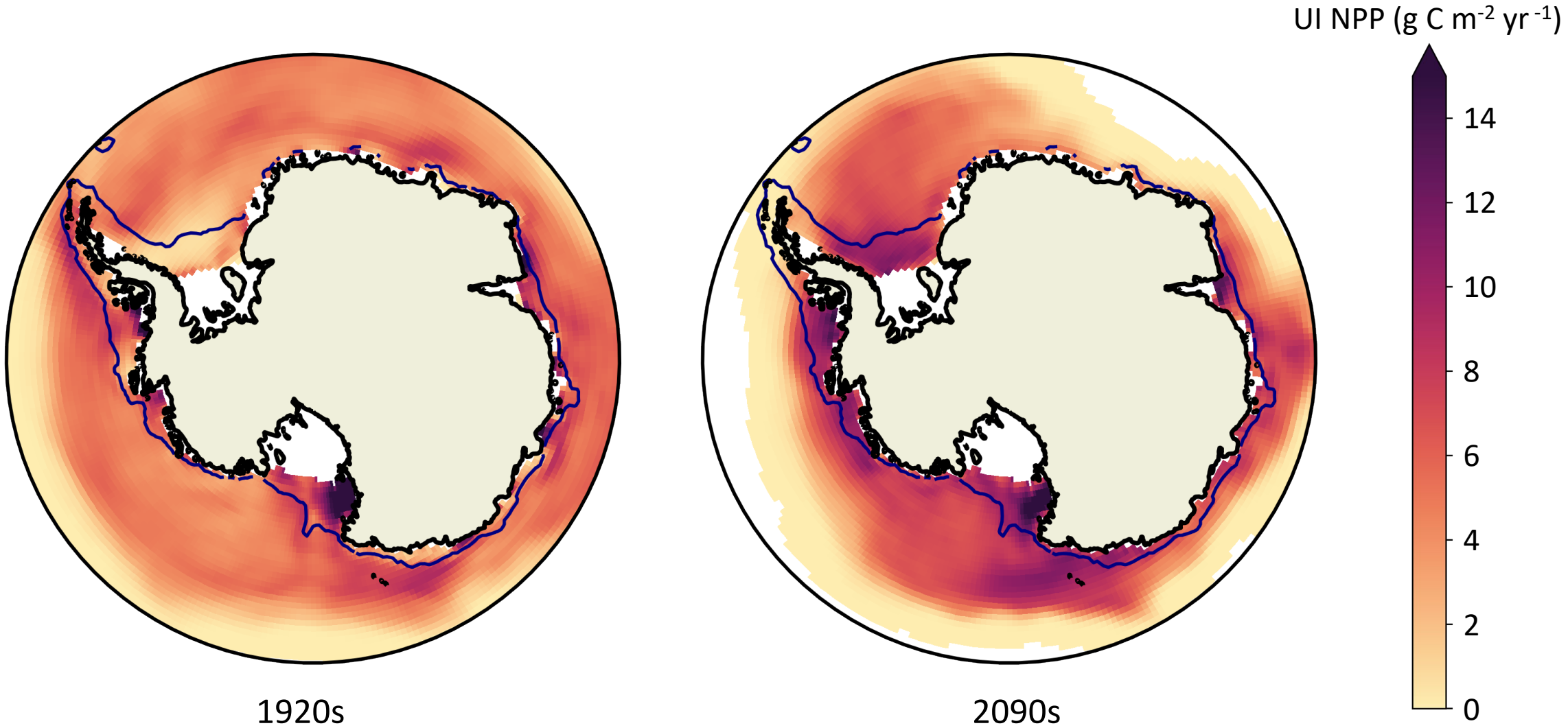
How does UI NPP change in its spatial distribution?



Arctic UI NPP shifts poleward into the deep central Arctic before declining substantially

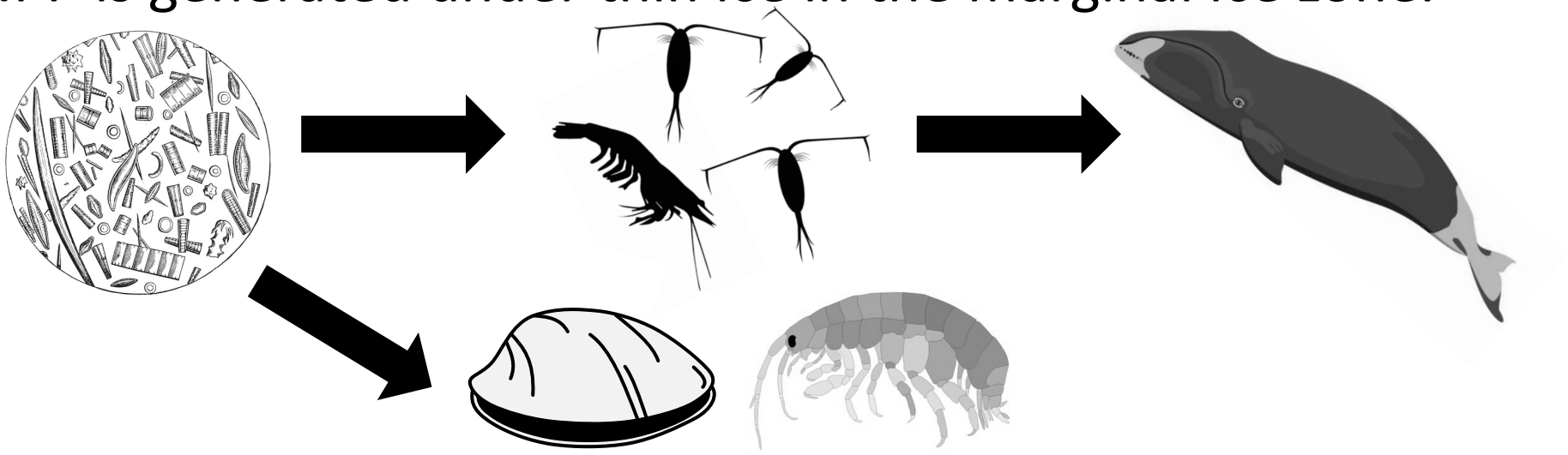


Antarctic UI NPP shifts poleward and onto continental shelves



Summary

- 200 Tg C yr^{-1} of NPP is generated under sea ice, split equally between the Arctic and Southern Oceans.
- NPP under ice is likely to shift poleward and decline in magnitude over time in both hemispheres.
- Arctic UI NPP is generated under consolidated, thick sea ice. Southern Ocean NPP is generated under thin ice in the marginal ice zone.

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