What lies beneath? Melting sea ice and conservation of Arctic benthic habitats

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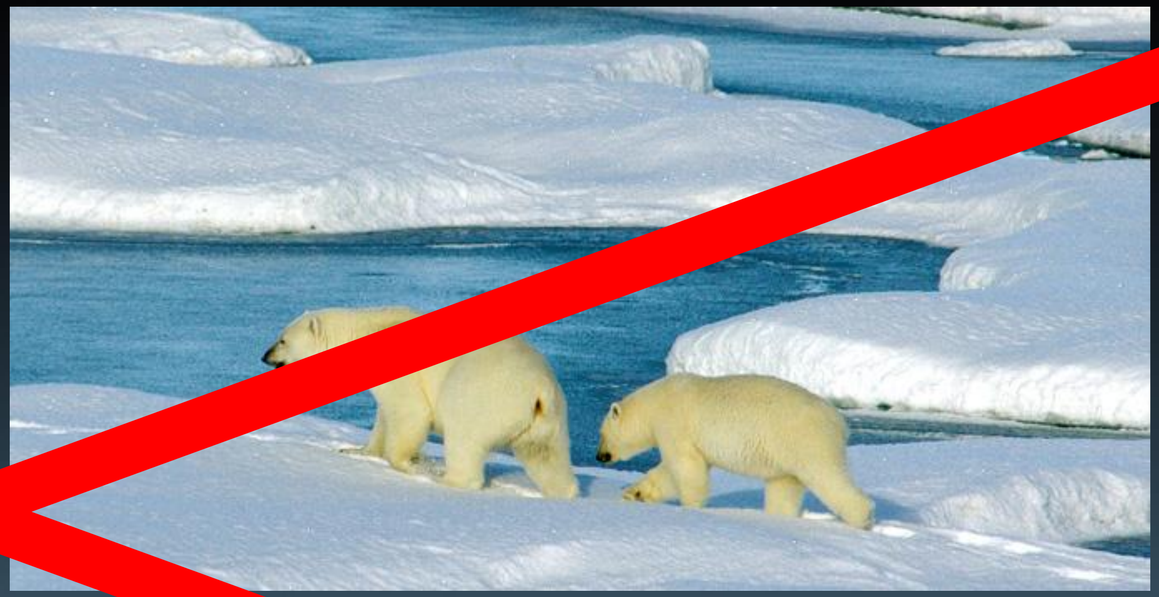
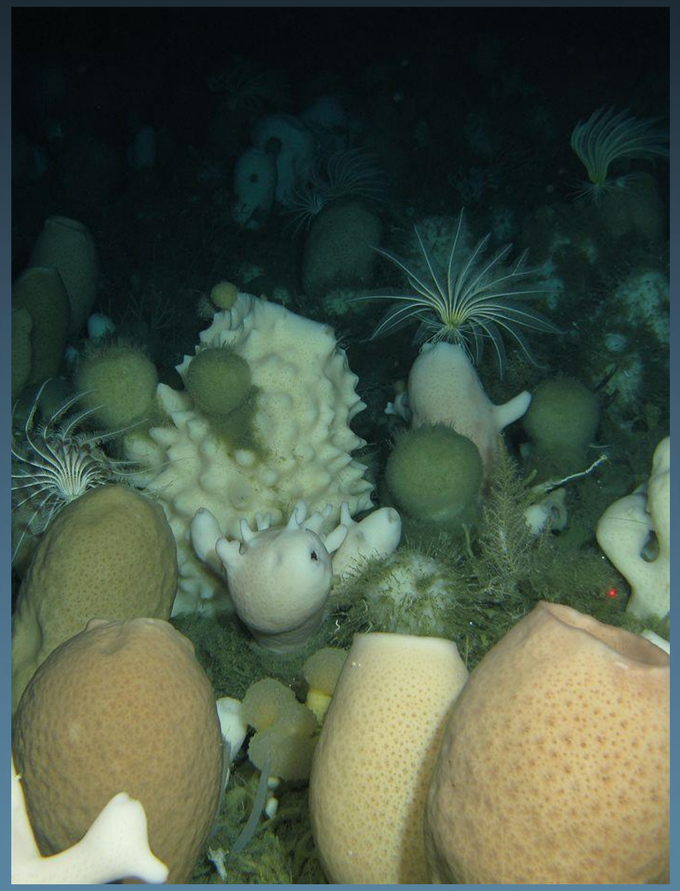
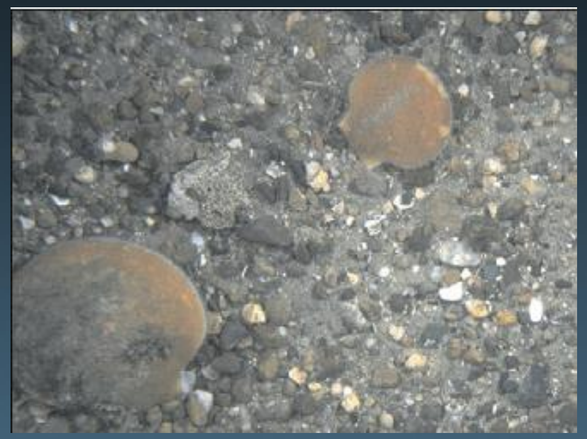
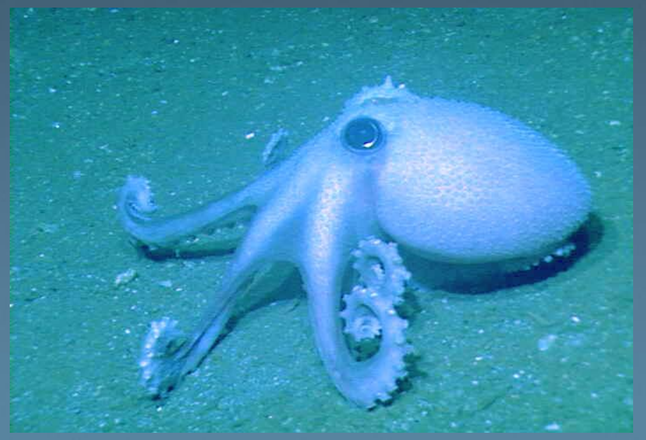
Conservation of Arctic Flora and Fauna

A Centre Collaborating with UNEP





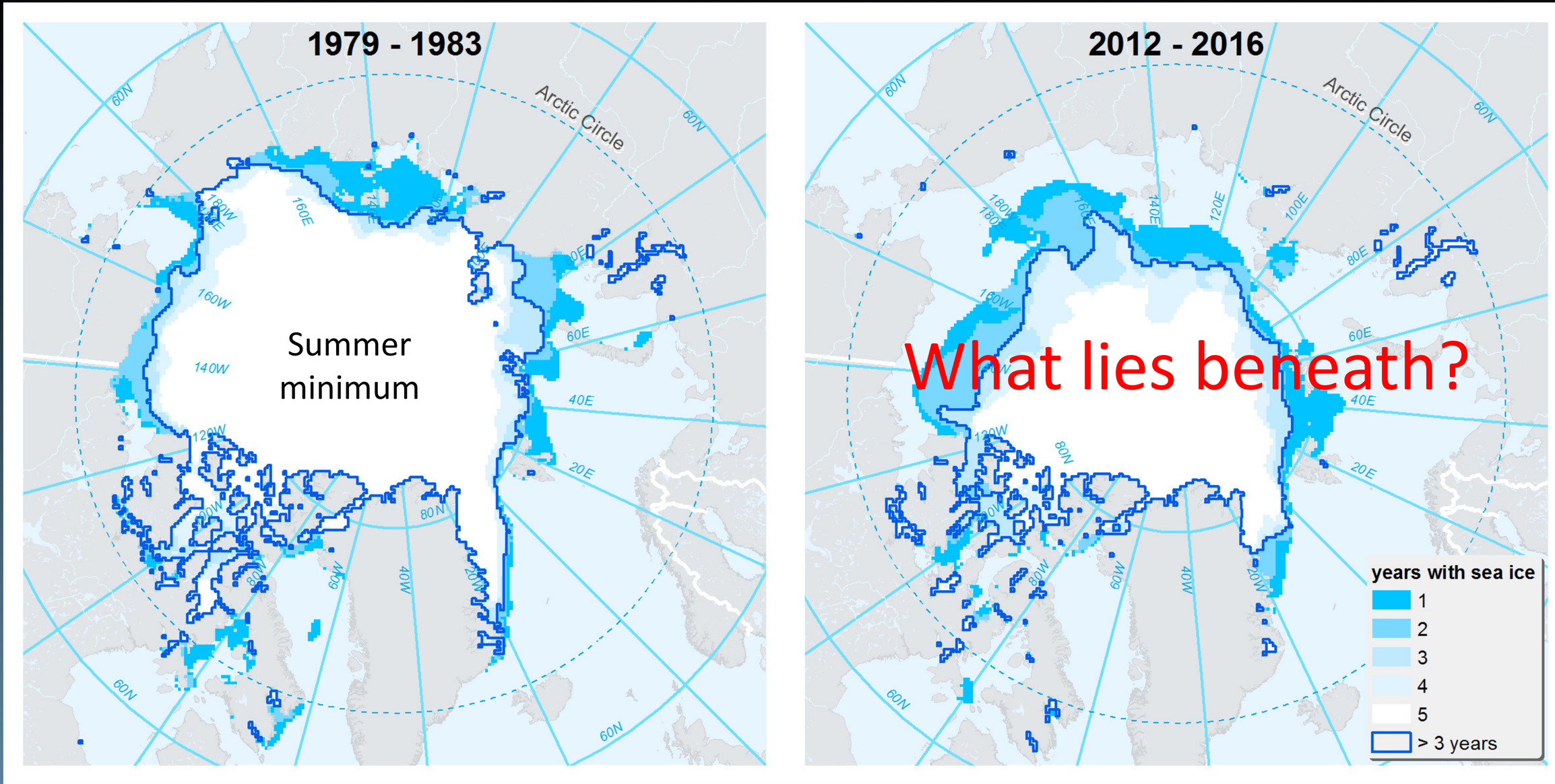




Profound changes in Arctic ecosystems due to climate change

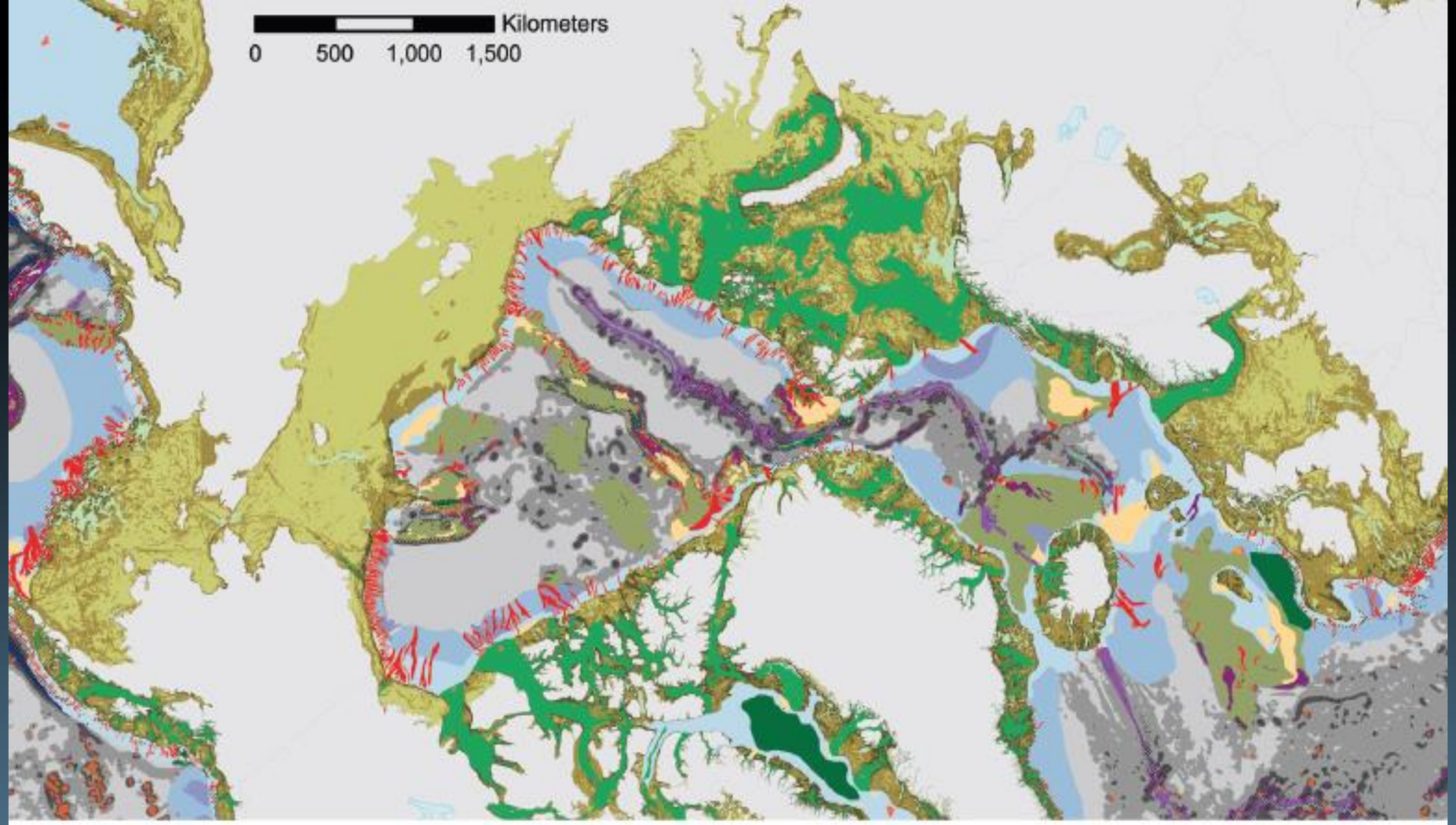
1. In a seasonally ice-free Arctic, more open-water conditions may result in a three-fold increase in primary productivity.
2. Absence of sea ice allows ocean-atmosphere coupling >>> currents, waves (coastal impacts), more surface mixing >>> regime shift.
3. Warmer ocean conditions have already caused changes to the ranges and ecology of Arctic fish, benthos, birds and mammals.

Shrinking sea ice from 7.5 million km^2 in 1979 to around 4 million km^2 in 2016



Source: National Snow and Ice Data Center, Sea Ice Index, Version 2 (Fetterer et al 2016) spatial resolution (pixel size) of 25 x 25 km.

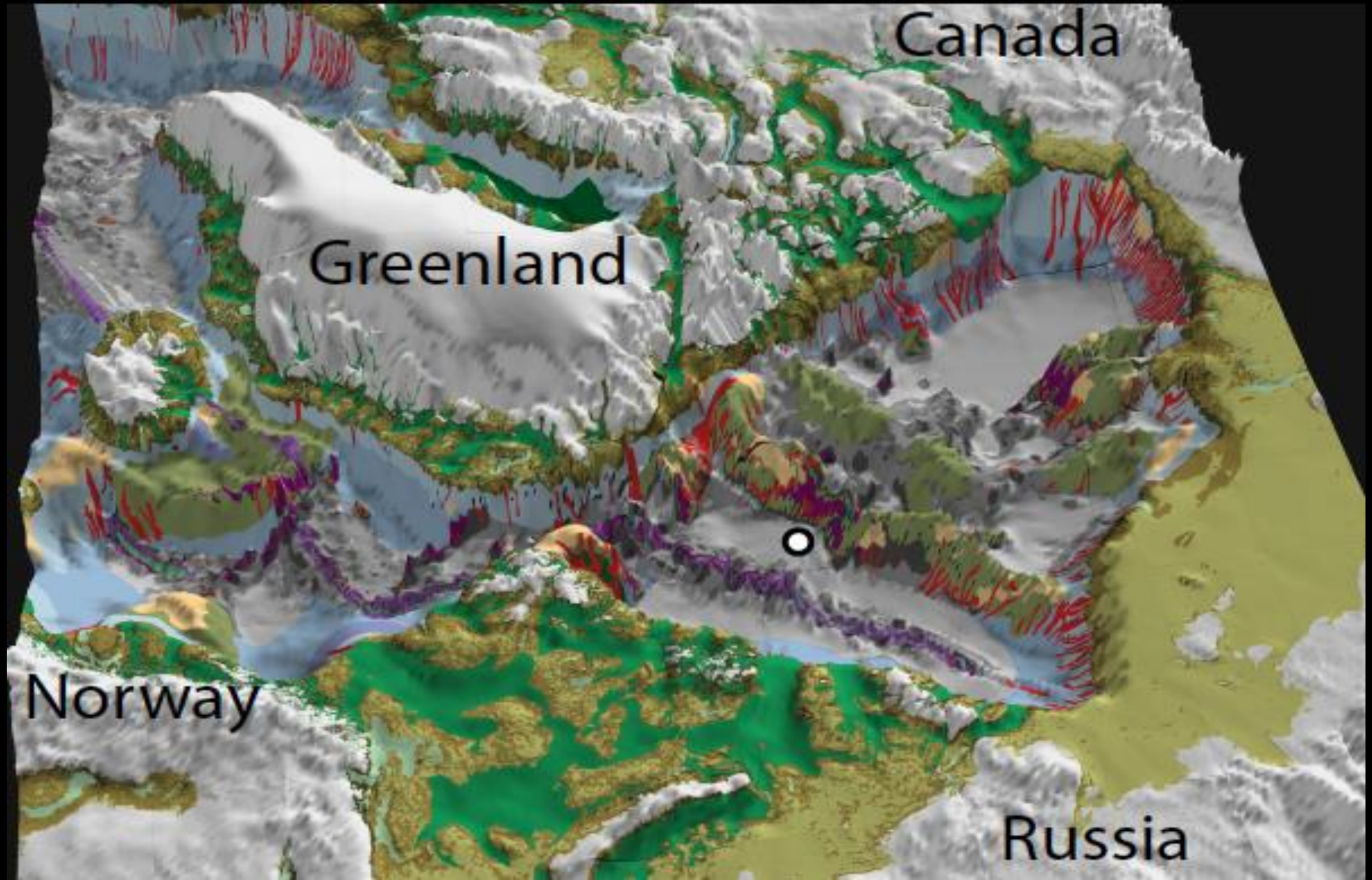
Seafloor geomorphic features

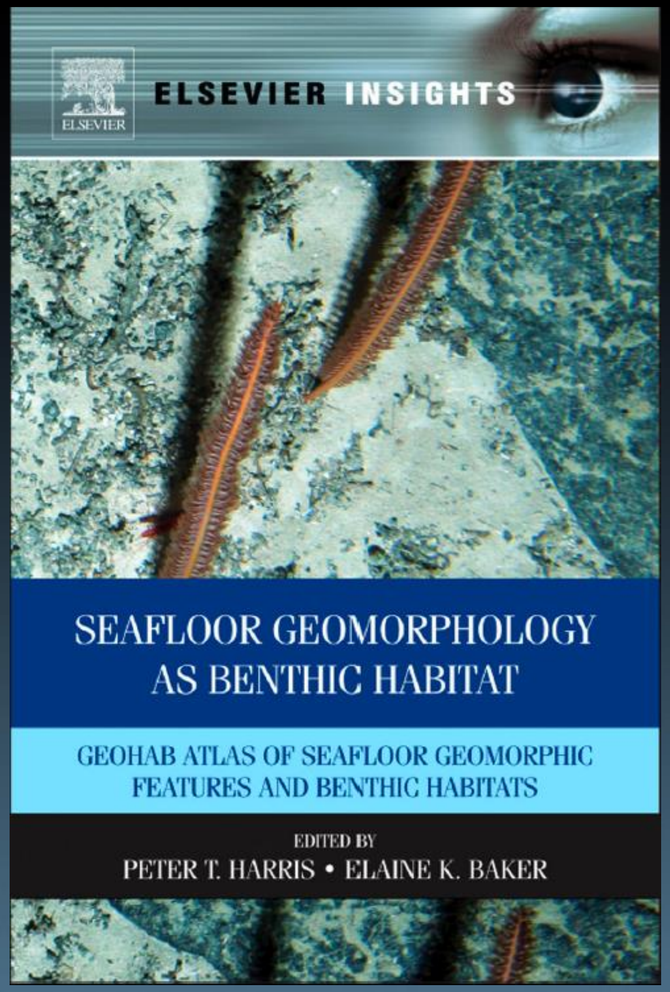


Shelf - high profile
Shelf - medium profile
Shelf - low profile
Slope
Abyss - mountains
Abyss - hills
Abyss - plains
Hadal
canyon
guyot
seamount
bridge
sill
escarpment
shelf valley
rift valley
glacial trough
trough
ridge
spreading ridge
fan/apron
rise
terrace
trench
plateau

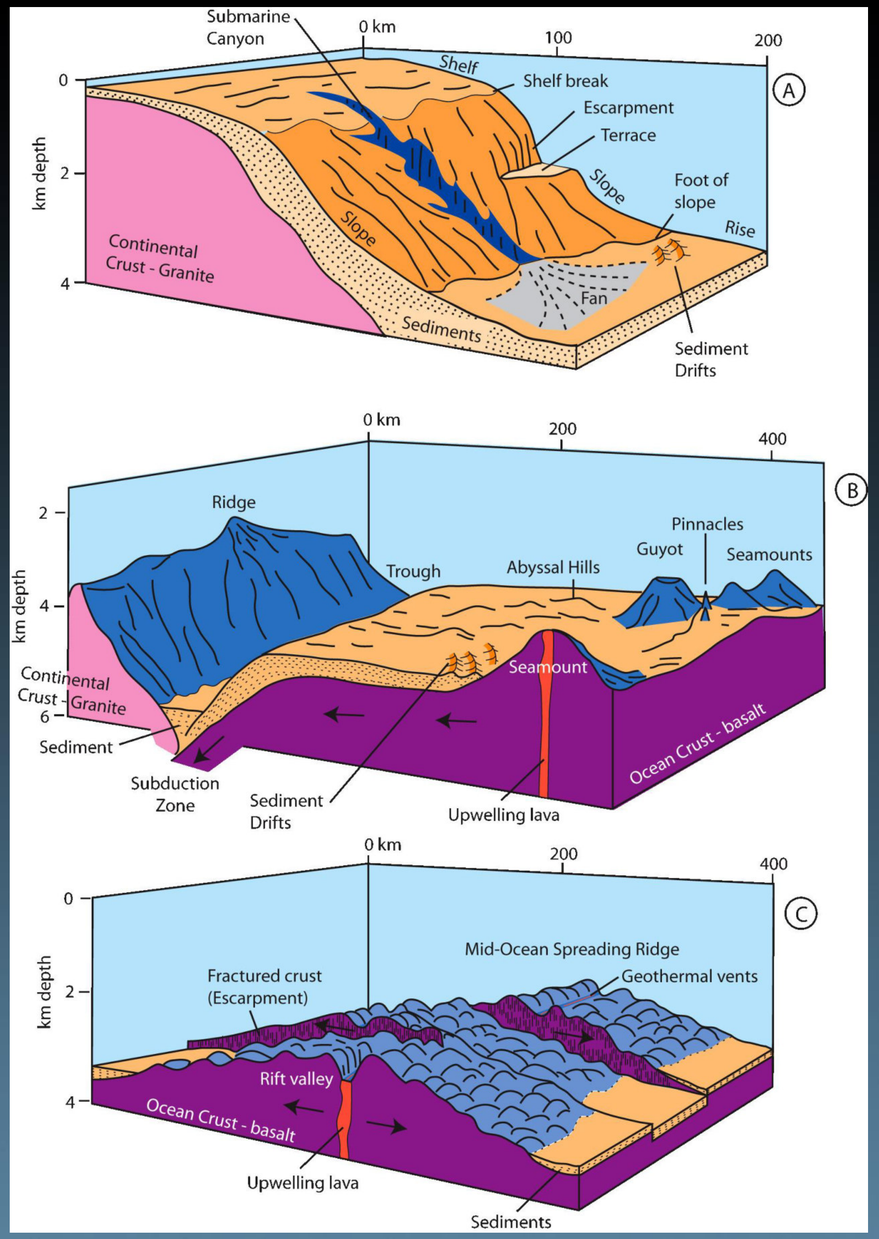
are also benthic habitats - seamounts, canyons, ridges and plateaus each support unique (endemic) benthic communities.

Harris, P.T., MacMillan-Lawler, M., Rupp, J., Baker, E.K., 2014. Geomorphology of the oceans. *Marine Geology* 352, 4-24.


Canada
Greenland
Norway
Russia



Harris and Baker, Eds. (2012). *Seafloor Geomorphology as Benthic Habitat: GeoHab Atlas of seafloor geomorphic features and benthic habitats.* Amsterdam, Elsevier.



Fernandez-Arcaya et al (2017). "Ecological Role of Submarine Canyons and Need for Canyon Conservation: A Review." *Frontiers in Marine Science* **4**(5).

Clark et al (2010). "The Ecology of Seamounts: Structure, Function, and Human Impacts." *Annual Review of Marine Science* **2**(1): 253-278.

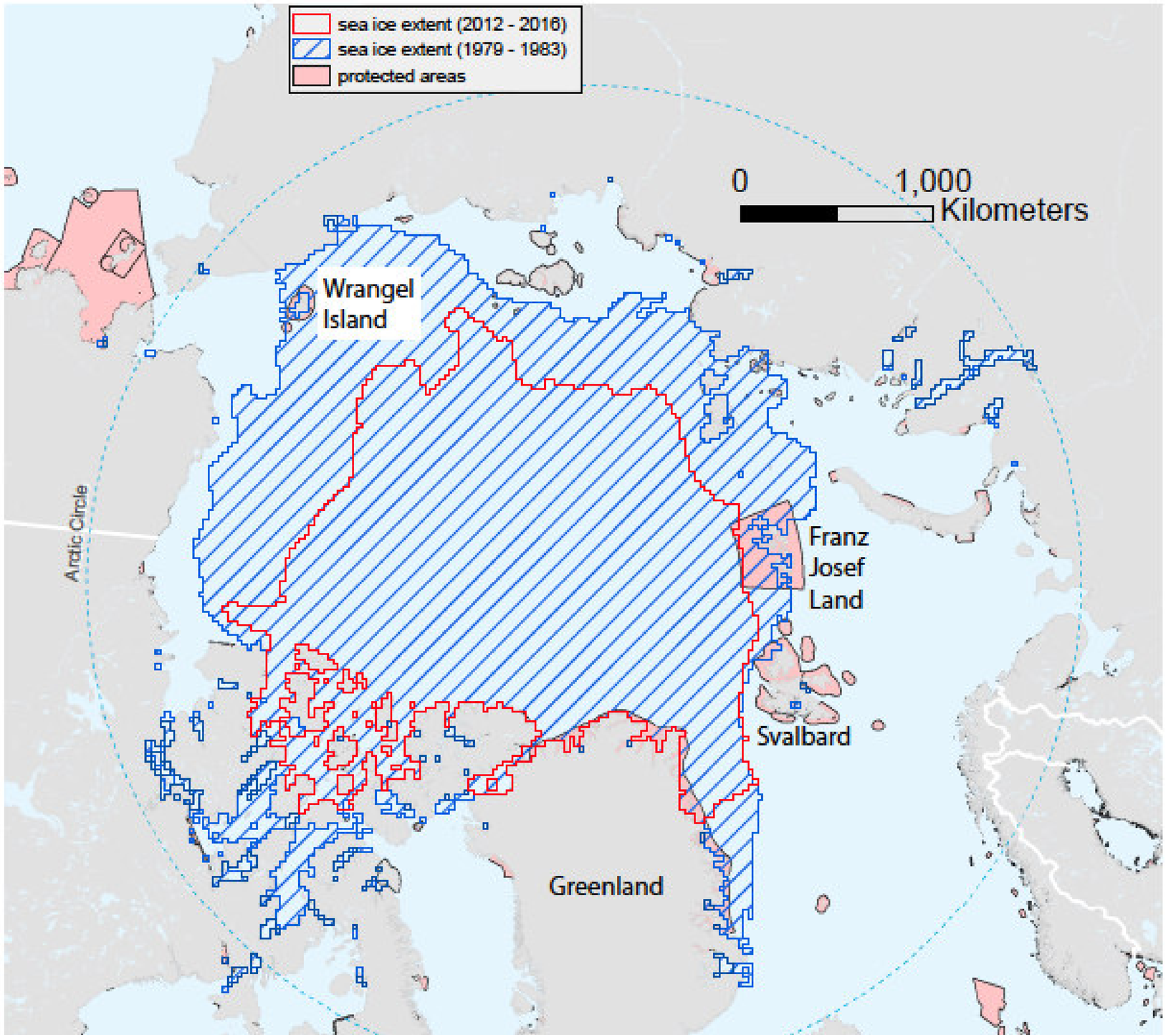
Jamieson et al (2010). "Hadal trenches: the ecology of the deepest places on Earth." *Trends in Ecology & Evolution* **25**(3): 190-197.

Van Dover, C. (2000). *The ecology of deep-sea hydrothermal vents*. Princeton University Press.

Marine protected area boundaries

IUCN and UNEP-WCMC database.

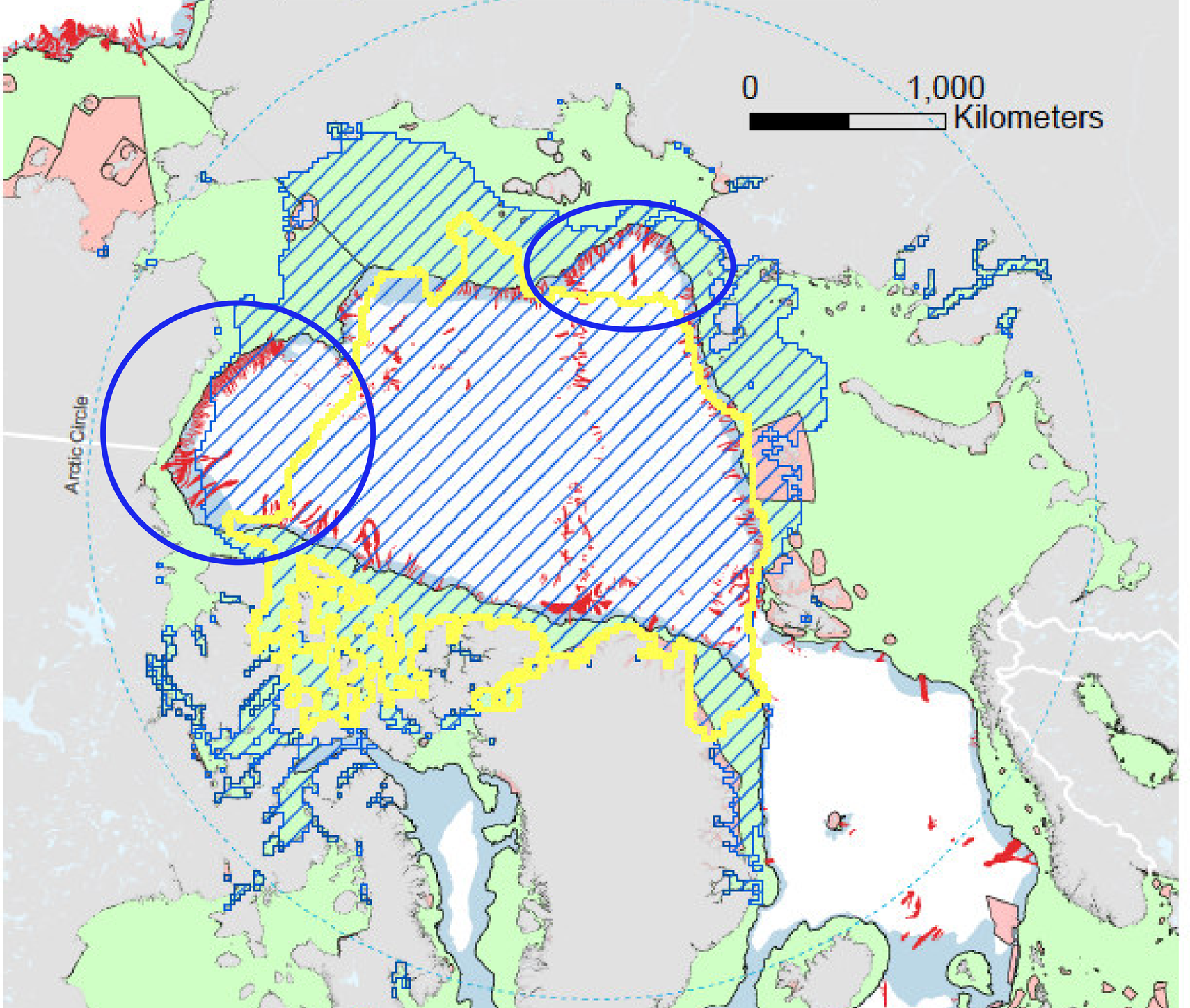
MPAs cover 173,000 km2 or 2.3% wrt (1979) permanent sea ice zone



37% of canyons now in open water

Submarine canyons contain potential fishing grounds, biodiversity hotspots, cold-water coral communities and cetacean feeding grounds. Shelf-incising canyons are associated with oceanographic upwelling zones and enhanced productivity.

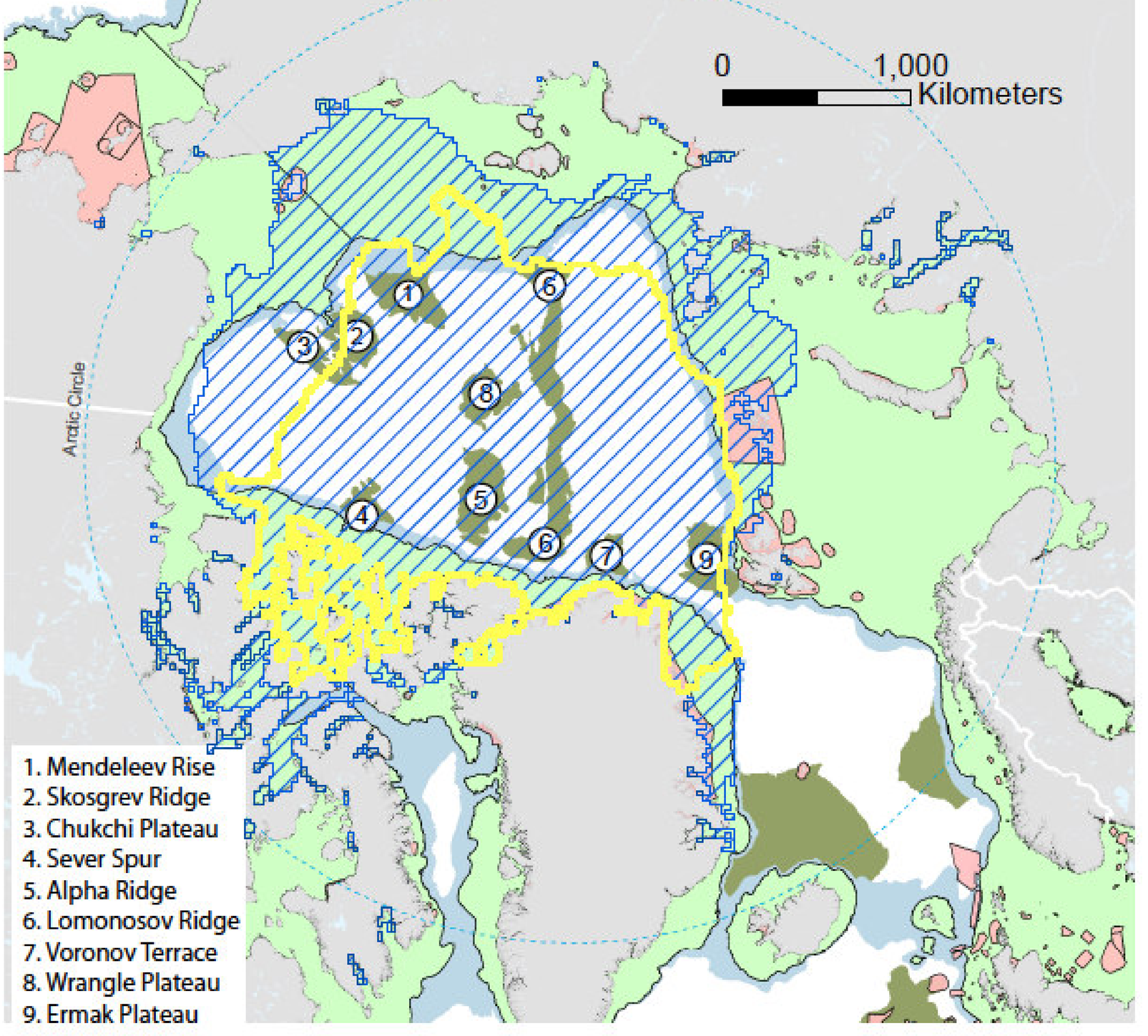
>400 Arctic canyons
295,000 km2
0.08% within MPAs

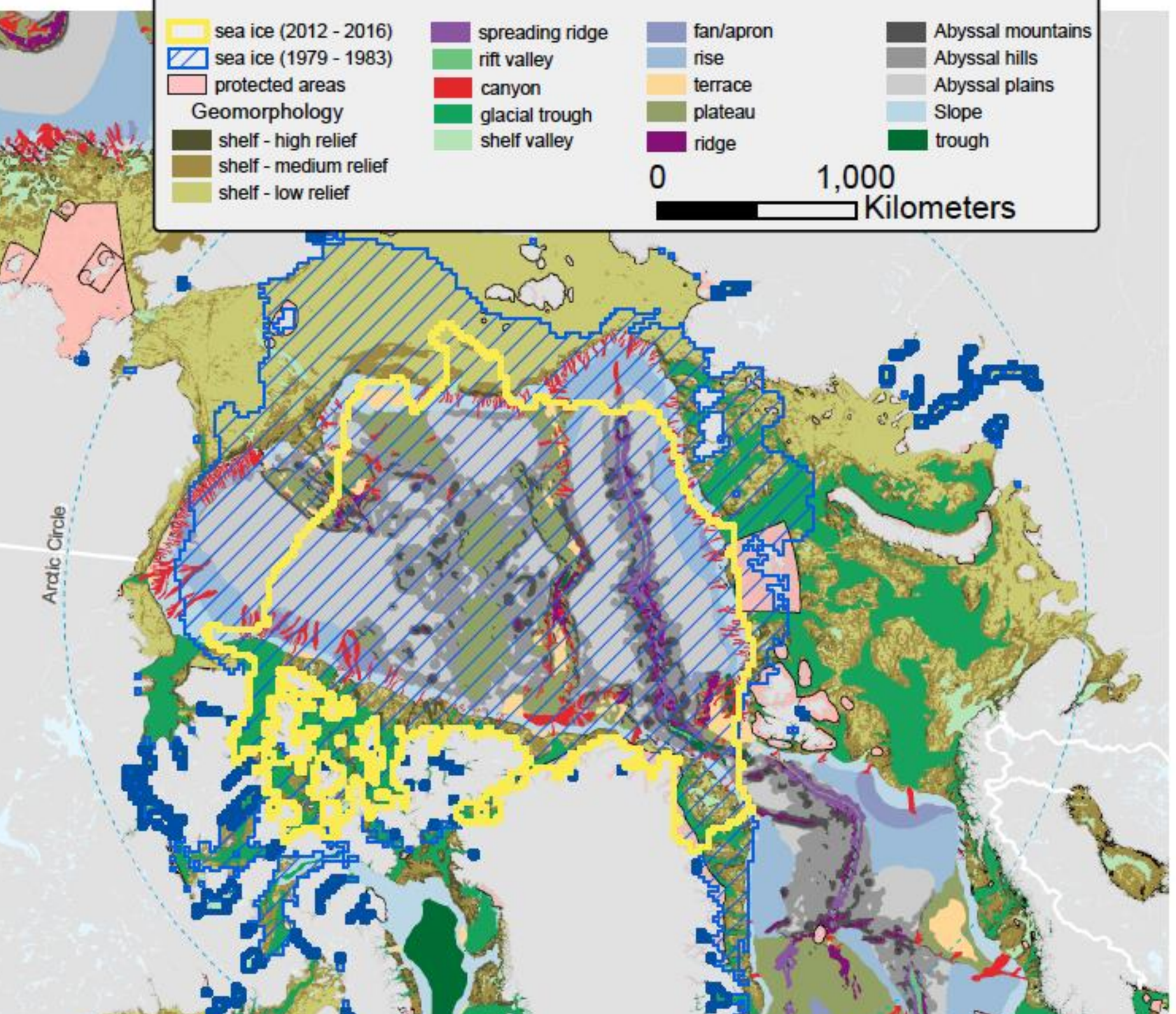


8.3% of plateaus now in open water

- Benthic ecology of submarine plateaus is poorly studied.
- Biodiversity is thought to be increased in association with rocky habitats (eg. along plateau margins).
- Bottom trawl fisheries impact plateaus in other areas.

773,000 km2
0% within MPAs





Geomorphology of the Arctic Ocean

Change in sea ice cover:

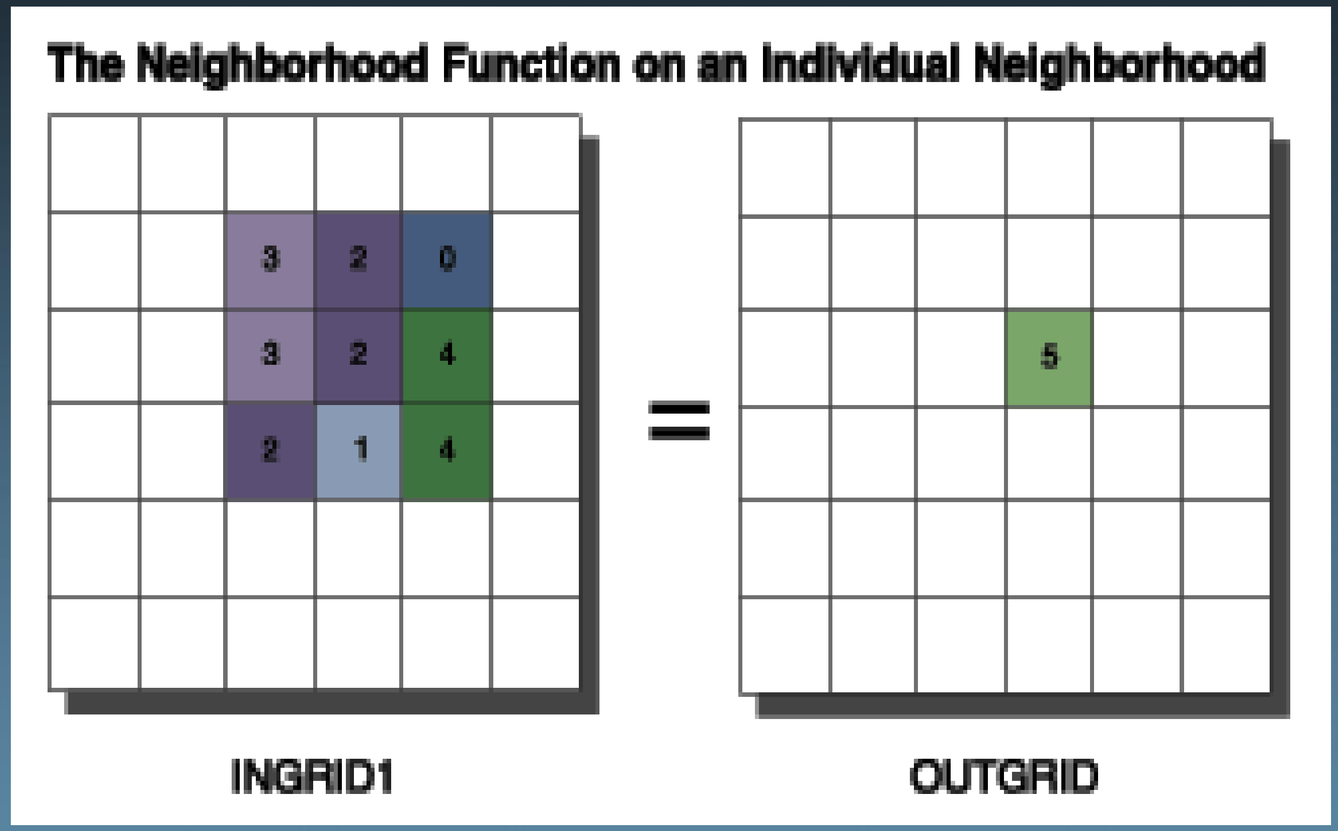
Shelf	65%
Glacial troughs	50%
Slope	48%
Submarine canyons	37%
Plateaus	8%
Abyssal plains	19%
TOTAL	38%

Conserved in MPAs:

Shelf	4%
Glacial troughs	5.7%
Slope	0.3%
Submarine canyons	0.08%
Plateaus	0%
Abyssal plains	0%
TOTAL	2.3%

Where to place MPAs to protect biodiversity?

Geomorphic features = habitats
Therefore diversity of seafloor geomorphology = benthic biodiversity.

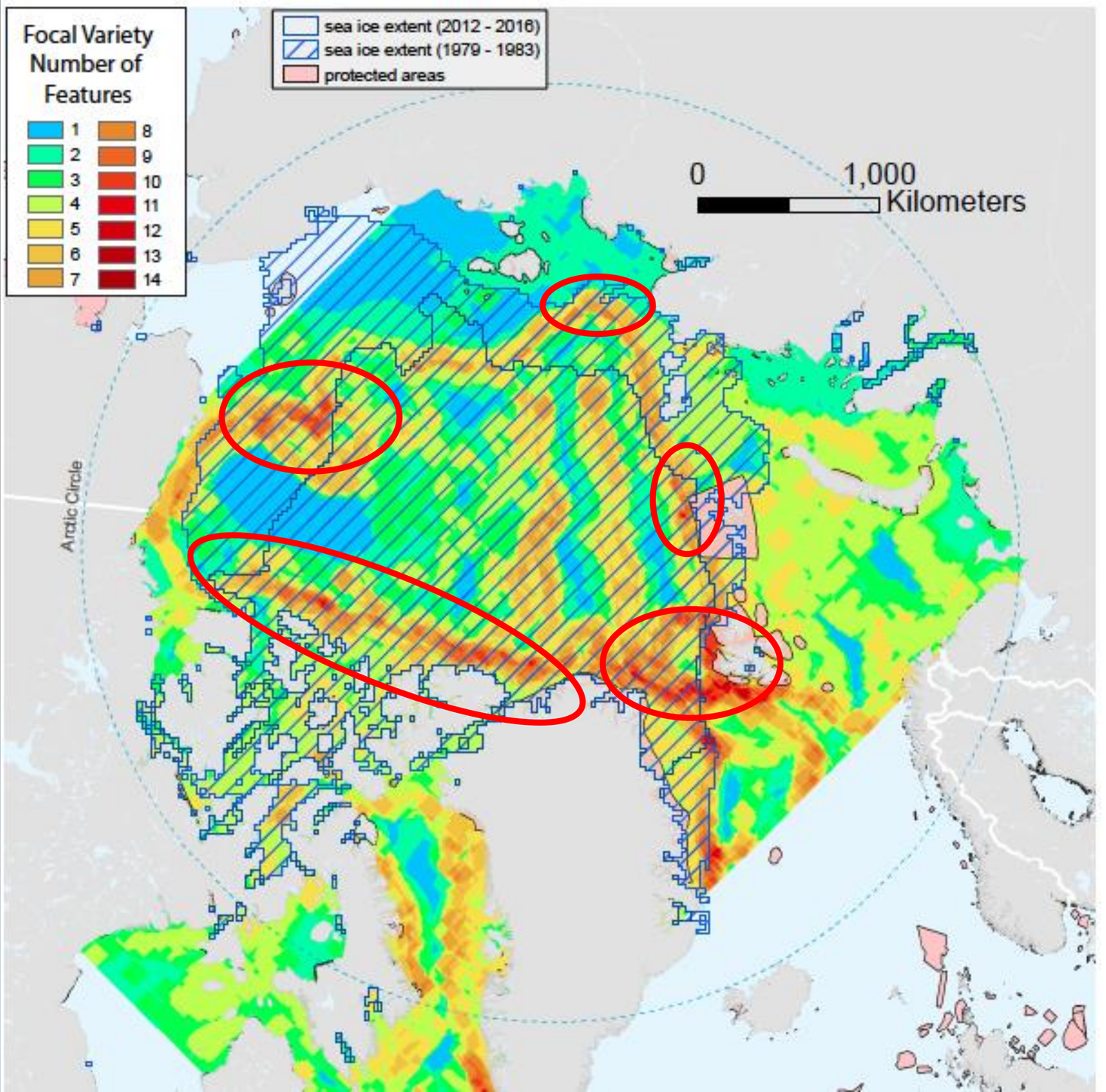


Convert map to raster file

Use focal variety
100 x 100 cell radius =
(100km x 100km)

heterogeneity is an estimate of biodiversity.

Heterogeneity hot spots suggest themselves as possible MPAs



Harris, P. T., M. MacMillan-Lawler, L. Kullerud and J. Rice (2018). "Arctic marine conservation is not prepared for the coming melt." ICES J. Mar. Sci. **75**(1): 61-71.

Conclusions

1. Mapping seafloor geomorphic features provides a consistent, ecologically meaningful approach to regional-scale MSP
2. Existing MPAs cover only 2.3% of the area under year-round sea ice circa 1979-84, located mainly along coastlines
3. Abyssal habitats are not included in existing MPAs and negligible protection is provided to slope habitats
4. Many habitats in near-pristine condition, never previously exploited, value to science as benchmarks for future research.
5. Species and ecosystems adapting to the new, post-anthropogenic climate change environment is a further consideration to protect and conserve these habitats.