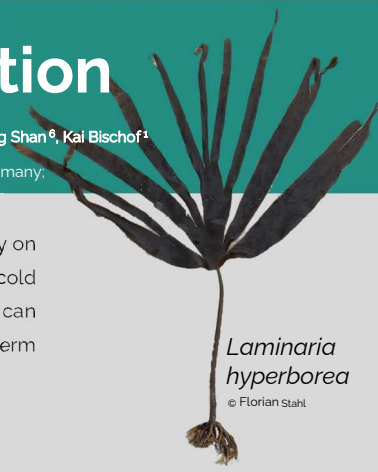


Interactive drivers affect kelp distribution

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Due to global temperature rises, models predict marine species to expand to higher latitudes. Most models are focusing solely on the thermal requirements of a species, even though it has become clear that temperature alone is a weak predictor for kelps' cold distribution limits: e.g., the ecosystem engineering species *Laminaria hyperborea* has not yet spread to the Arctic, although it can survive and tolerate the prevailing temperatures. To investigate its ability to spread poleward in future, we conducted a long-term experiment, exposing kelp specimens from Northern Norway to different photoperiods at 0°C, 5°C and 10°C.

Research questions: (1) Why has *Laminaria hyperborea* not yet spread to higher latitudes?
(2) Will it spread to polar regions in future?

Three-month experiment with all conditions being below the species' optimum

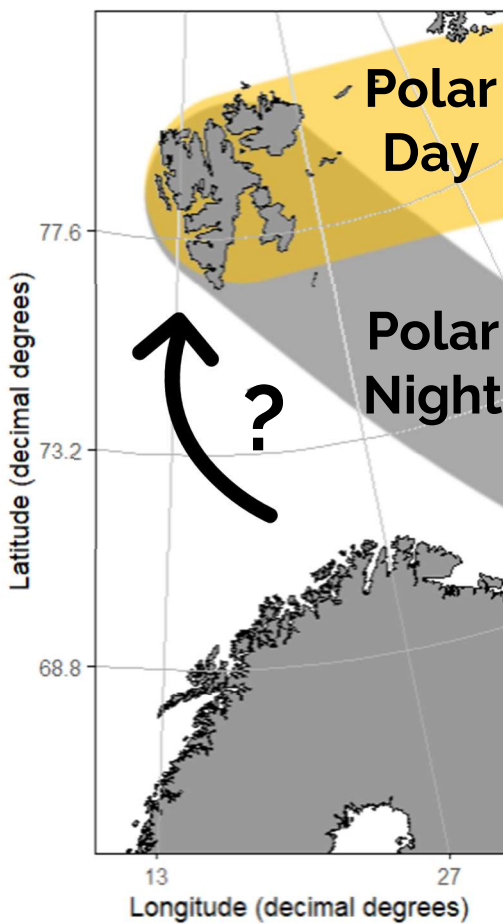
- ↔ No change
- ↑ Increase
- ↓ Decrease



Present-day, cold temperatures



Near-future, warm temperatures



↓ Physiological vitality
↓ Photosynthetic pigments

↔ Physiological vitality
↑ Storage carbohydrates

↔ Physiological vitality
↔ Storage carbohydrates

↔ Physiological vitality
↔ Storage carbohydrates

Cold temperatures interacting with **long photoperiod** can prevent the spread of temperate kelps to higher latitudes.

Climate change induced warming allows invasion to Arctic regions.

→ **Photoperiod acts as additive stressor!**

→ **Altered kelp ecosystem functioning**

- (1) We found cold temperatures interacting with polar day to prevent the spread of *L. hyperborea* to higher latitudes.
- (2) Rising temperatures mitigate the high-light stress, potentially facilitating the spread of *L. hyperborea* in the near-future.

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