

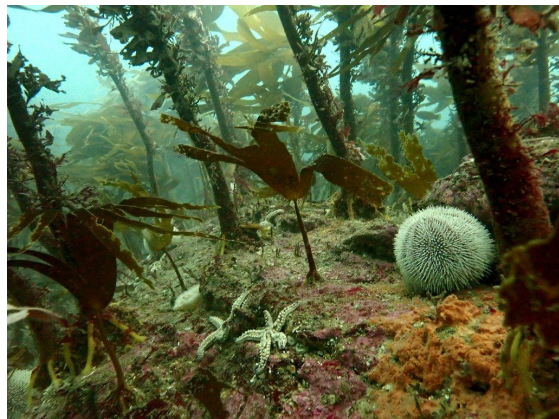
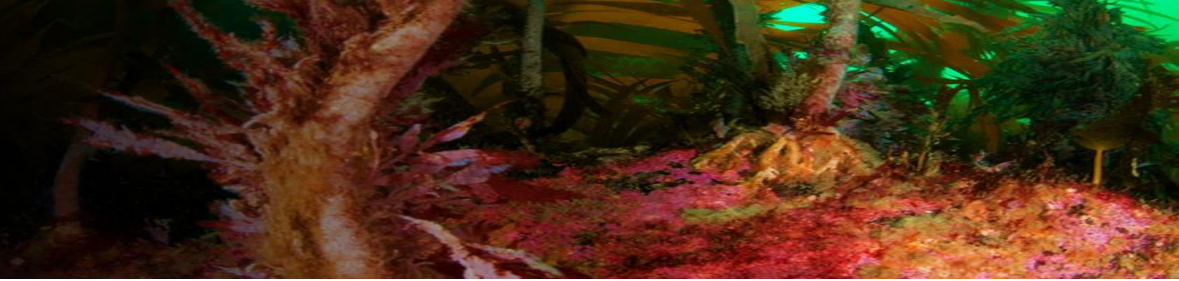


LIFE ON THE FOREST FLOOR:  
Spatio-temporal variation in  
*Laminaria hyperborea*  
understorey assemblages

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Hannah Earp, Dan Smale, Jacob Bestwick,  
Brandon Frazel, Nathan King, Pip Moore

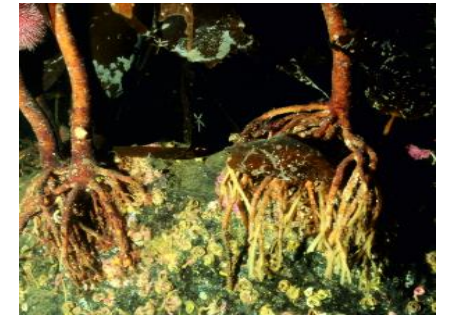
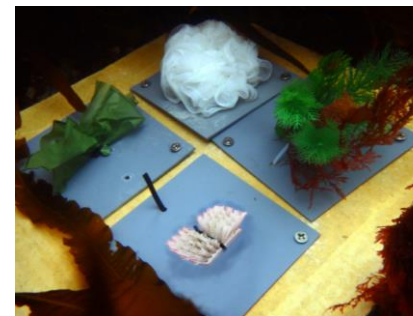
# Underwater forests



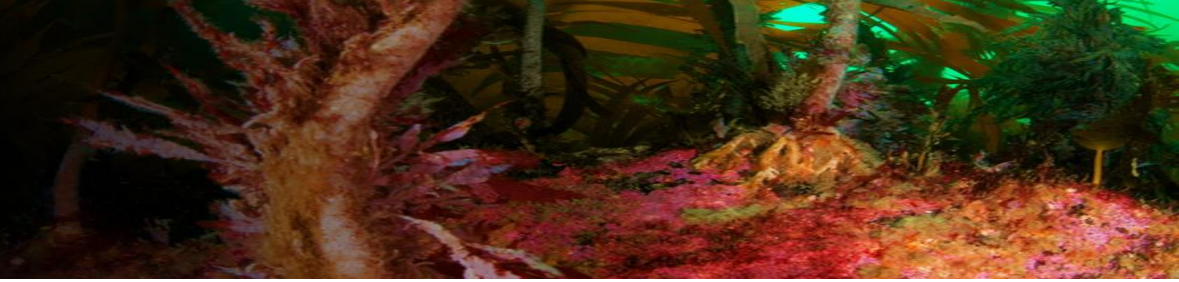
# What do we know?

## Variation in the structure of:

- 🌿 Kelp forest (Smale & Moore 2017)
- 🌿 Holdfast assemblages (Teagle et al. 2018)
- 🌿 Stipe assemblages (King et al. 2021)
- 🌿 Understorey algae (Smale et al. 2020)
- 🌿 Understorey fauna in ASUs (Bué et al. 2019)



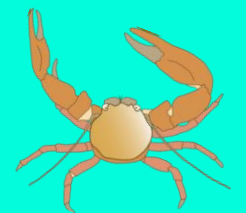
# What don't we know



- 🌿 Understorey fauna directly associated with understorey algae
- 🌿 Change in over time
- 🌿 Drivers of variation
- 🌿 Stochastic events

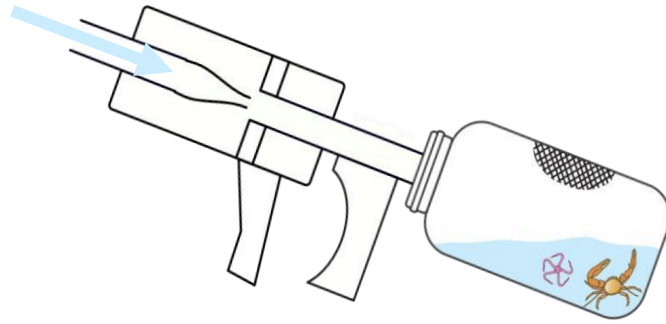


**MISSION:** Investigate spatial & temporal variation in understorey assemblage structure within UK *Laminaria hyperborea* forests

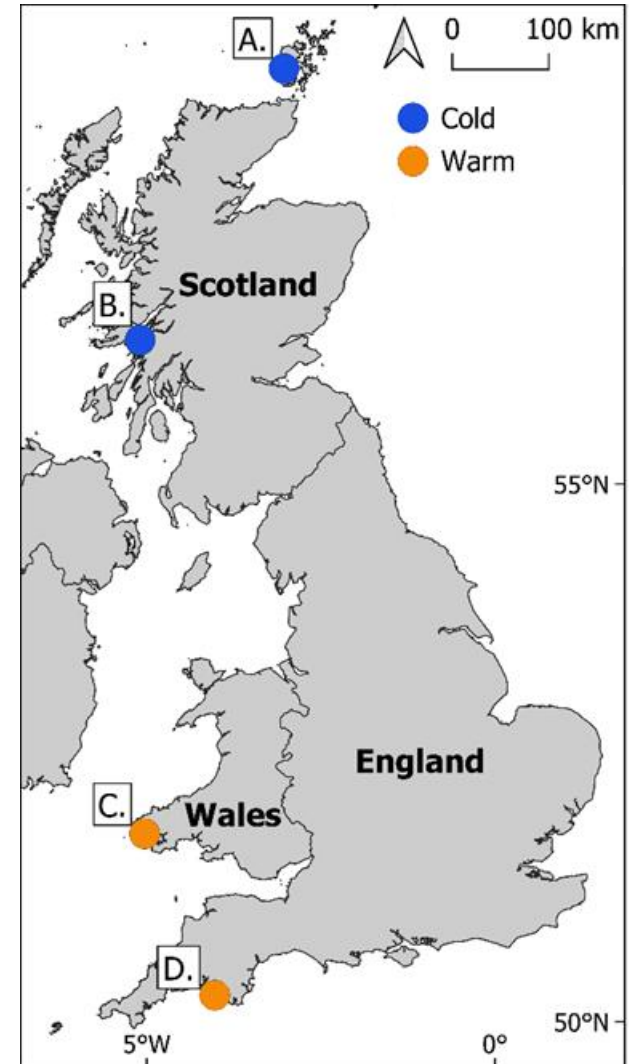


# The adventure

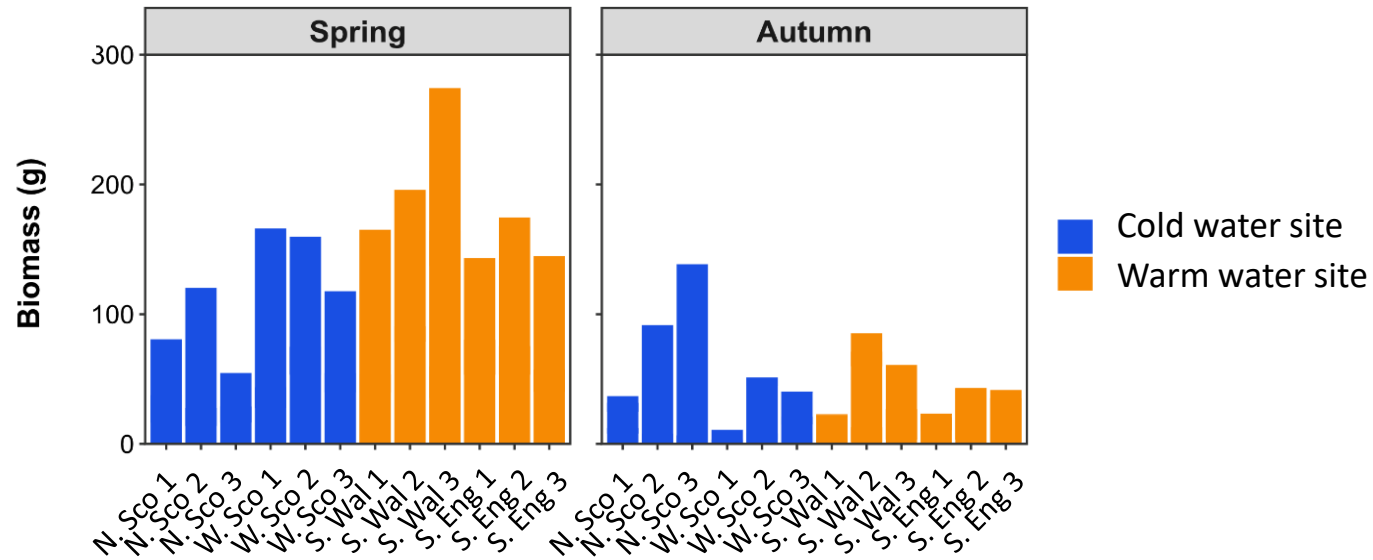
- 🌀 12 sites across 4 regions
- 🌀 Spring & Autumn 2017
- 🌀 Underwater suction sampler



- 📖 Algae: to functional groups & dried
- 📖 Fauna: to lowest taxa possible
- 📖 Environmental conditions: diver surveys, WF model, BIO-oracle
- 📖 Statistics: Primer



# What did we find - Algae



↑ biomass in spring

↑ **functional groups** in autumn, particularly at warm water sites

PERMANOVA: significant seasonal differences across sites

SIMPER: seasonal dissimilarity (35%) driven by ↑ spring biomasses of **foliose + corticated foliose** & **filamentous** algae

# What did we find - Fauna



>65, 300 individuals from 179 taxa

# What did we find - Fauna



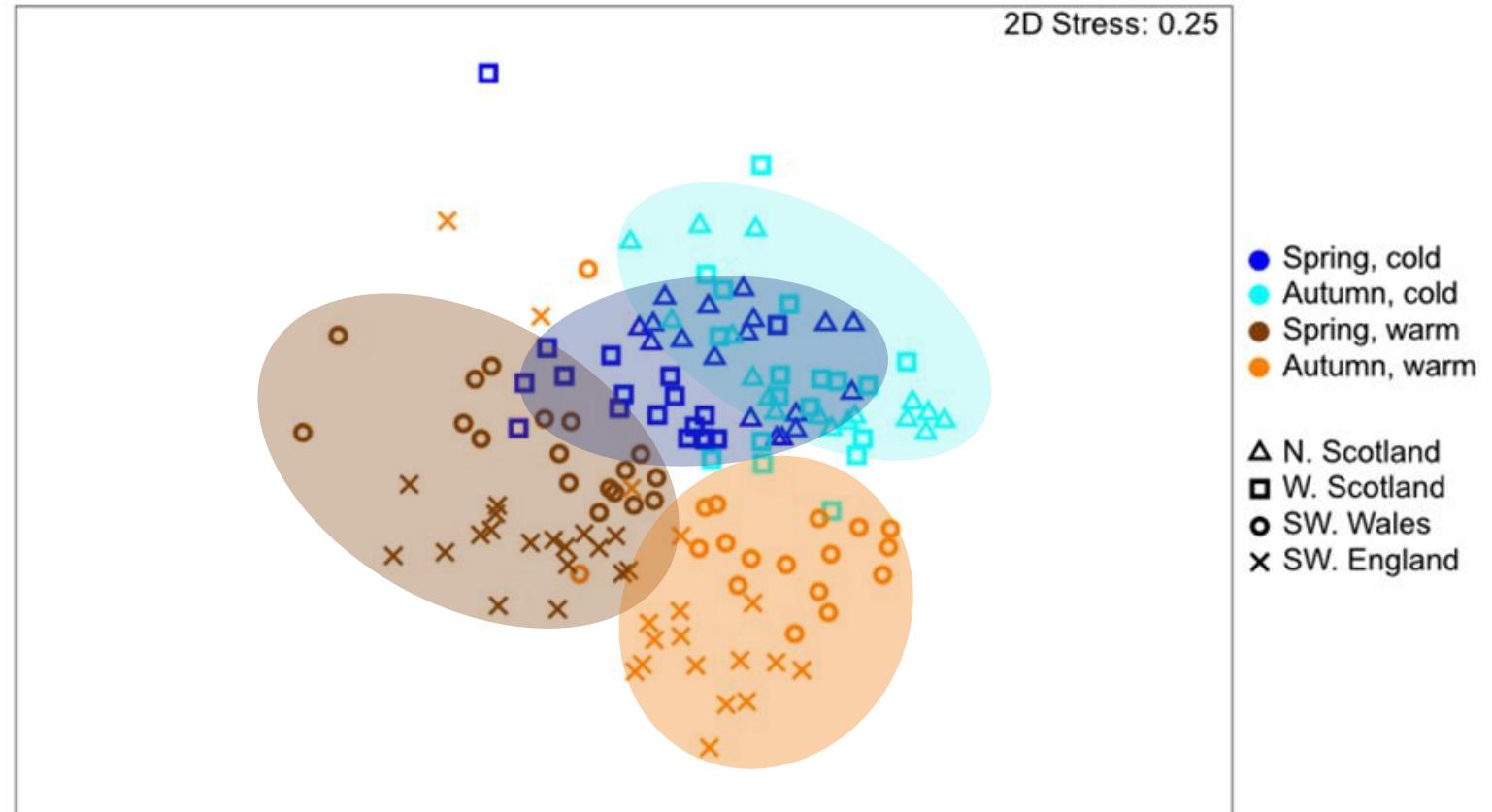
🐞 **Spring:** ↑ gastropods & bivalves

🐞 **Autumn:** ↑ amphipods

🐞 **Cold water sites:** ↑ gastropods

🐞 **Warm water sites:** echinoderms & polychaetes

🐞 **PERMANOVA:** significant seasonal differences across sites



# What did we find - Fauna



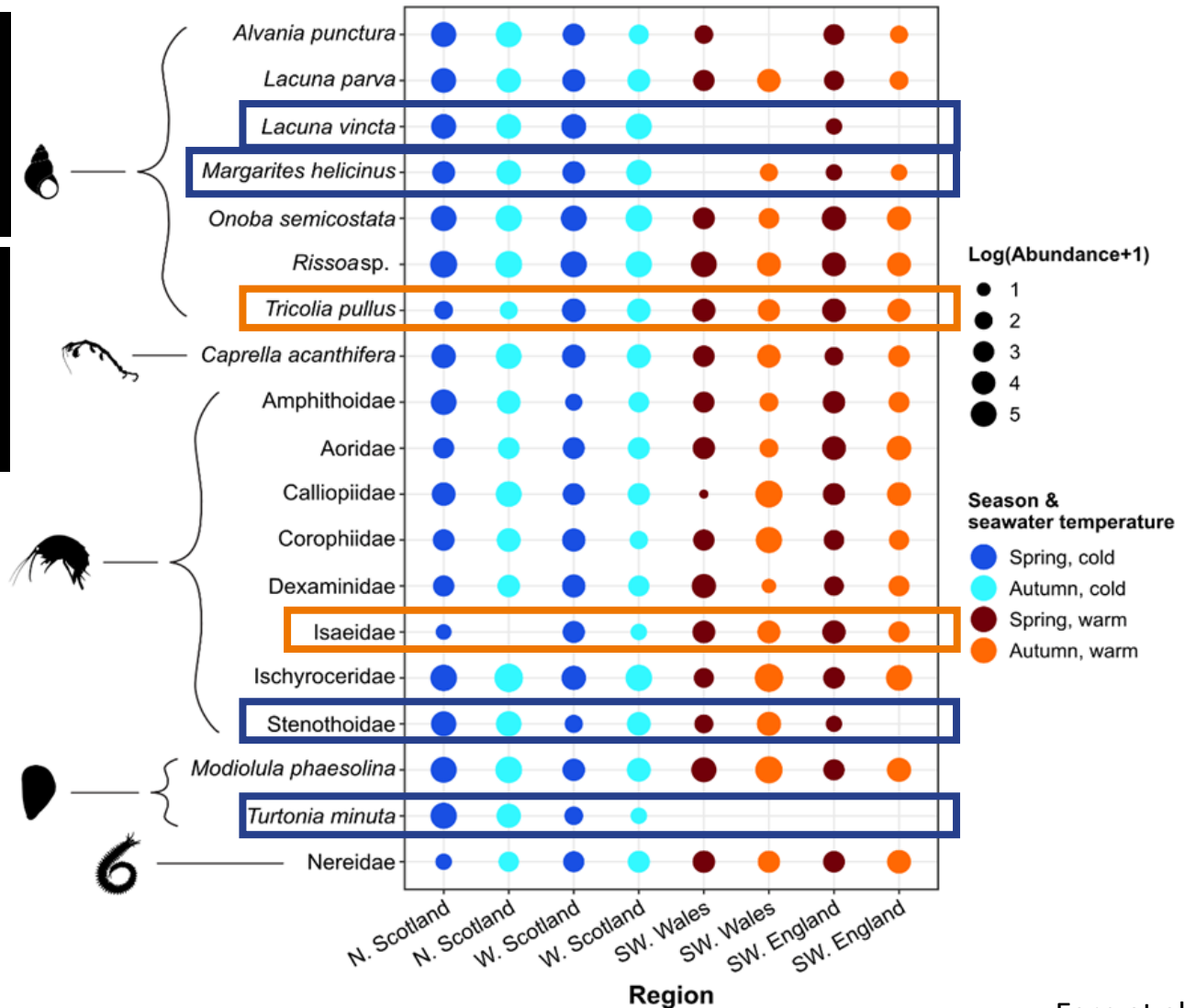
Spring: ↑ gastropods & bivalves

Autumn: ↑ amphipods

Cold water sites: ↑ gastropods

Warm water sites: echinoderms & polychaetes

SIMPER: dissimilarity spread across several taxa



# What did we find - Drivers

distLM

## Algae

- ✓ Sediment/detritus weight
- ✓ **Sea surface temperature**
- Wave exposure**
- Chlorophyll *a* concentration
- Nitrate concentration
- ✓ **Phosphate concentration**
- L. hyperborea* density

Most parsimonious model: 11%

## Fauna

- ✓ **Understorey filamentous biomass**
- ✓ Understorey foliose + corticated foliose biomass
- Understorey corticated biomass
- ✓ Understorey leathery biomass
- ✓ Understorey articulated calcareous biomass
- ✓ Sediment/detritus weight
- ✓ **Sea surface temperature**
- ✓ **Wave exposure**
- ✓ *L. hyperborea* density
- ✓ *L. hyperborea* age

Most parsimonious model: 36%

# What does it mean?



🧠 Diverse & abundant understorey

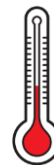


273.3g m<sup>2</sup>



7,308 inds m<sup>2</sup>

🧠 Complex interactions among environmental variables likely drive local variability



🧠 Baseline for comparison

# Thank you for your attention



Award No: TT22/1245



Award No: 2022\_BPS\_0106



## WEATHERING THE STORM: The response of *Laminaria hyperborea* & associated understory assemblages to storm disturbance

Hannah Earp<sup>1,2</sup>, Dan Smale<sup>3</sup>, Peter Almond<sup>3</sup>, Harry Cathalán<sup>3</sup>, Adam Gouraguine<sup>3</sup>, Cat Wilding<sup>3</sup>, Pippa Moore<sup>3</sup>

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<sup>2</sup>Newcastle University

### What is the problem?

Kelp are foundation species that inhabit temperate rocky coastlines where they facilitate the development of understory assemblages and provide food and shelter for a diverse array of organisms.  
Kelp forest structure is influenced by various abiotic factors including storm-driven wave action that can have profound effects on these valuable ecosystems.  
With storms expected to increase in frequency and intensity, it is important to understand how storms may influence the structure of kelp forests and their associated assemblages.

### NE Atlantic Storm Season 21/22

During the 2021/22 NE Atlantic storm season, the UK was subject to several intense storms of which the most severe was Storm Arwen from 25-27 November 2021. Storm Arwen was one of the most powerful and damaging storms of the last decade and significantly impacted the north-east coastline.

**Storm Arwen**  
Wind gusts: > 100 kph  
Wind Direction: North  
Wave Height: 7.2 m  
Wave Period: 8.5 s

**Pre-storm** → **Post-storm**

### What did we do?

We investigated the impact of the 2021/22 NE Atlantic storm season on associated assemblages along the NE coast of the UK.

3x sites NE, England  
3x sites SE, Scotland

In June 2021 (pre-storm) and March 2022 (post-storm), SCUBA-divers undertook:  
 - 3-5x 25 m transect surveys of *L. hyperborea* canopy cover.  
 - 10x 1 m<sup>2</sup> quadrat surveys of *L. hyperborea* abundance & structure.  
 - 5-10 *L. hyperborea* sampled for morphology, biomass & age.  
 - 6x 0.0825 m<sup>2</sup> quadrats suction sampled for understory flora & fauna.

### What did we find?

*L. hyperborea* forest structure was significantly altered by the storm season.

The storm season significantly reduced *L. hyperborea* canopy cover. Post-storm season, the number of canopy *L. hyperborea* individuals were smaller &/or had a lower biomass.

The storm season only significantly impacted the abundance & diversity of understory macrofauna at two sites.

The storm season significantly altered the structure of understory macrofaunal assemblages. This dissimilarity in structure was spread across multiple taxa.

**Results Fast Facts**  
 Av. ± SD length of canopy *L. hyperborea*:  
 Pre = 23.7 ± 6.0 cm  
 Post = 17.2 ± 4.2 cm  
 Av. biomass ± SD of canopy *L. hyperborea*:  
 Pre = 1,408 ± 230 g DW m<sup>-2</sup>  
 Post = 595 ± 108 g DW m<sup>-2</sup>  
 No. of understory macrofaunal individuals:  
 Pre = 1,057  
 Post = 236  
 No. of understory taxa:  
 Pre = 50  
 Post = 31

### Why is it important?

The storm season significantly altered the structure of *L. hyperborea* forests & understory macrofauna assemblages which will likely influence ecosystem functioning & ecosystem service provision.

There appeared to be a degree of resilience and/or recovery from storm impacts at some sites, however site-level variation indicates that further research is required to fully understand the impact of storms on kelp forests.

NERC  
Newton Fund  
British Ecological Society  
British Phycological Society  
The Challenger Society for Marine Science

References: Earp et al. (2021) *Marine Ecology Progress Series* 659: 439-450  
 Turner & Underhill (2015) *Marine Pollution Bulletin* 91: 611-614

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