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Loss of seagrass driven by marine heatwave in Shark Bay Marine Park and World Heritage Area

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Background

The increased occurrence of extreme climate events, such as marine heatwaves (MHWs), has resulted in substantial ecological impacts worldwide. Metrics of thermal stress within marine systems have predominantly focussed on coral communities, and less is known about measuring stress relevant to other primary producers, such as seagrasses. However, seagrasses are also prone to heat stress, and particularly those growing near the northern limit of their biogeographic range. Such communities grow extensively in Shark Bay, which is dominated by the slow growing meadow-forming temperate seagrasses *Amphibolis antarctica* and *Posidonia australis*.

An extreme MHW occurred along much of the Western Australian coastline in the austral summer of 2010/2011, exposing marine communities to summer seawater temperatures 2-5 °C warmer than average. Using a combination of satellite imagery and seagrass monitoring, detailed maps were produced to show the seagrass coverage across the entire Shark Bay World Heritage Area (approximately 13,000 km^2) before (2002, 2010) and after the MHW (2014, 2016), and explore which measures of heat intensity and exposure best explain the spatial variation in seagrass loss.

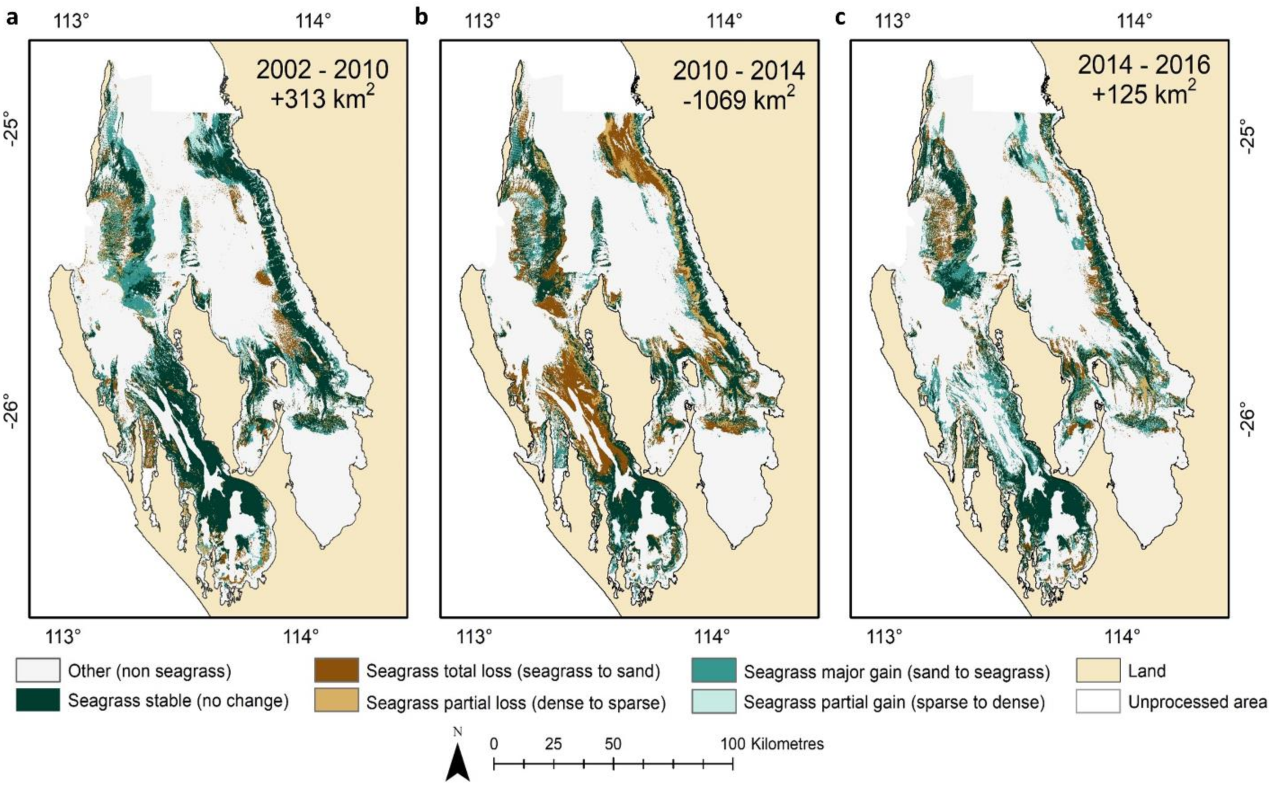

Figure 1. Change in seagrass extent (km^2) across Shark Bay World Heritage Area between (a) 2002–2010, (b) 2010–2014 and (c) 2014–2016. Seagrass 'total loss' is classified as a pixel change from either dense or sparse seagrass to bare sand; 'stable' category as no change, 'major gain' category from bare sand to dense or sparse seagrass, 'partial gain' is change from sparse to dense seagrass and 'partial loss' is from dense to sparse seagrass. Overall accuracy = 75% and κ = 0.55.

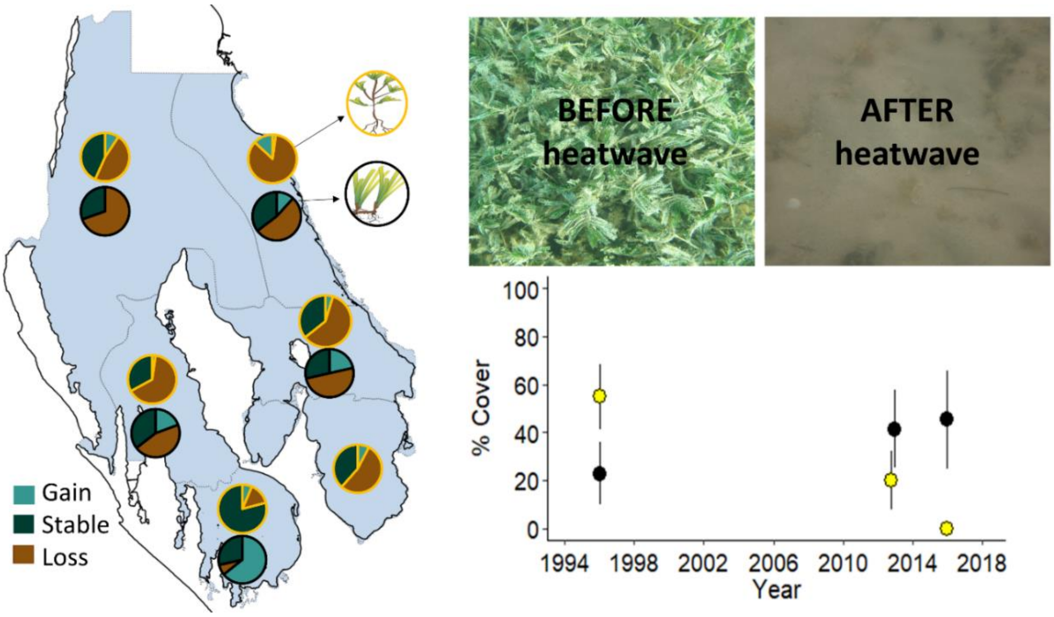

Figure 2. *Left:* Proportion of seagrass change between 2010 and 2014 coloured by category (seagrass loss, gain, stable) for *A. antarctica* (yellow outline) and *P. australis* (black outline) for each region across the World Heritage Area. *Top right*: underwater image of dense *A. antarctica* in 2010, and the same Monkey Mia site in 2014. *Bottom right*: Mean percent cover (±SE) of *A. antarctica* (yellow) and *P. australis* (black).

Findings

- Our temporal analysis of seagrass mapping documents the single largest loss in dense seagrass extent globally (1,310 km^2) following an acute disturbance.
- Change in seagrass extent differed across Shark Bay, with severe declines occurring in the Western Gulf and Wooramel Bank, and minimal loss in Freycinet Basin (Figure 1).
- Spatial variation in seagrass loss was best explained by a model that included an interaction between two heat stress metrics. The most substantial loss occurring when seagrass experiences a combination of extreme sea surface temperatures (i.e. ≥ 1°C above previously experienced maximum temperatures), sustained for long periods of time (i.e. 94 days or more).
- Change in seagrass cover was predominantly due to loss of *A. antarctica* (Figure 2).
- There was some recovery of seagrass between 2014 and 2016, particularly in the Western Gulf.

Management implications

- The extent of the loss of dense seagrass recorded after an extreme climatic event demonstrates that MHWs are a major threat to seagrasses and the ecosystem services they provide in the Shark Bay Marine Park and World Heritage Area. Quantifying the change in extent and the potential drivers of change are crucial steps towards understanding the impact of MHWs on important benthic habitats such as seagrasses.
- As the intensity and frequency of MHWs are expected to increase due to climate change, it is important to identify the best metrics for describing the relationship between marine heat stress and ecological impacts. This research shows that extreme heat stress over prolonged periods is associated with higher seagrass loss and provides a basis for predicting the impact of MHWs in the future and a baseline for measuring seagrass adaption/acclimation.
- These results provide the basis for mapping areas of meadow degradation, stability or recovery, which may be used to identify areas resilient or susceptible to heat stress in the marine park and World Heritage Area. This information may also be used to highlight susceptible areas when assessing impacts from other stressors.

Further information

Strydom, S., Murray, K., Wilson, S., Huntley, B., Rule, M., Heithaus, M., Bessey, C., Kendrick, G. A., Burkholder, D., Fraser, M. W. & Zdunic, K. Too hot to handle: Unprecedented seagrass death driven by marine heatwave in a World Heritage Area. *Global Change Biology,* (http://doi.org/10.1111/gcb.15065)