Primary Drivers of Marine Heatwaves in the Northwest Atlantic

Robert W. Schlegel [1,2,*]
@robwschlegel
robert.schlegel@dal.ca
Ke Chen[2] Eric C. J. Oliver[1]

[1] Department of Oceanography, Dalhousie University, Halifax, Nova Scotia, Canada
[2] Physical Oceanography Department, Woods Hole Oceanographic Institution, Woods Hole, Massachusetts, USA

Introduction

- Marine heatwaves (MHWs) are 5+ day long events when temperature anomalies exceed the 90th percentile climatology (Hobday et al., 2016, 2018).
- There are many different drivers of MHWs known around the world (e.g. Olita et al., 2007; Deser et al., 2010; Bond et al., 2015; Schlegel et al., 2017; Oliver et al., 2018).
- Are there common/recurrent drivers of MHWs in the NW Atlantic?
- If so, can these be detected/clustered/quantified by a machine?

Methods

- SST pixels within each region of the coast (Figure 1A) were meaned together into one time series.
- MHWs were calculated from these 6 mean time series (Figure 1B).
- The start and end dates of each MHW were used to create mean synoptic air/sea state anomalies (Figure 2).
- These mean anomalies were fed to a self-organising map (SOM) to produce the 12 most common air/sea states (nodes).
- Humans are then used to infer the drivers from the 12 nodes.

Results

- To see all of the results please follow the QR code.
- The node 9 results show a clear Nor'easter pattern (Figure 3B).
- The centre of the high SST anomaly (Figure 3A) has a deepening MLD and negative downward heat flux (Figure 3C).
- Most MHWs occurred northwest of the centre of the SST anomaly (Figure 4A) due to the downward heat flux and shoaling MLD (Figure 3C).
- None of these events occurred in summer (Figure 4B), and nearly half occurred on the Newfoundland Shelf (Figure 4C).

Conclusions

- The nodes show three predominant patterns:
  - Warm Gulf Stream + air pushing up from south along the coast.
  - Warm air sitting over the entire coast during summer.
  - Warm air pushed over the Atlantic from the southeast onto the coast.
- The most intense MHWs occur during Autumn/Winter when large scale atmospheric patterns look like Summer MHW conditions.

The most intense marine heatwaves occur during autumn/winter when atmospheric patterns look like summer marine heatwave conditions

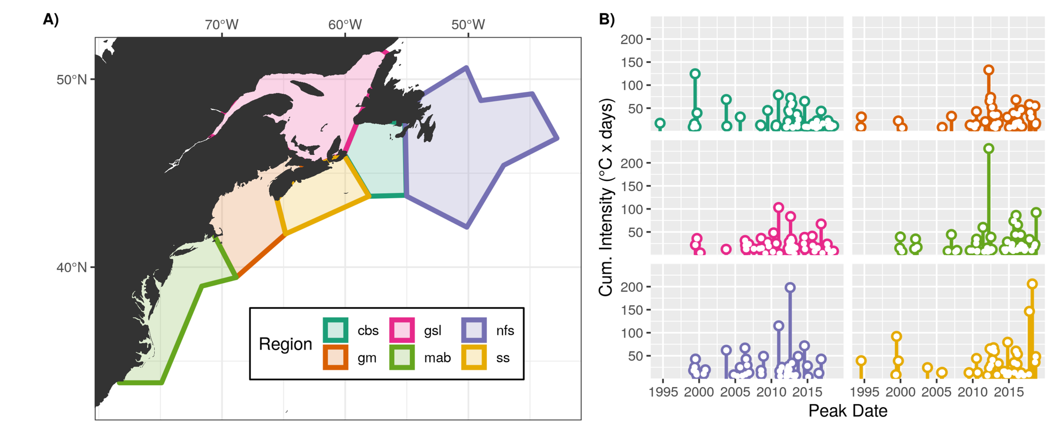

Figure 1: The regions of the study area and the marine heatwaves (MHWs) detected within them. The region abbreviations are: gm = Gulf of Maine, gls = Gulf of St. Lawrence, ls = Labrador Shelf, mab = Mid-Atlantic Bight, nfs = Newfoundland Shelf, ss = Scotian Shelf. A) The regions of the coast were divided up by their temperature and salinity regimes based on work by Richaud et al. (2016). B) The SST pixels within each region were averaged to one time series before detecting MHWs with the Hobday et al. (2016) definition.

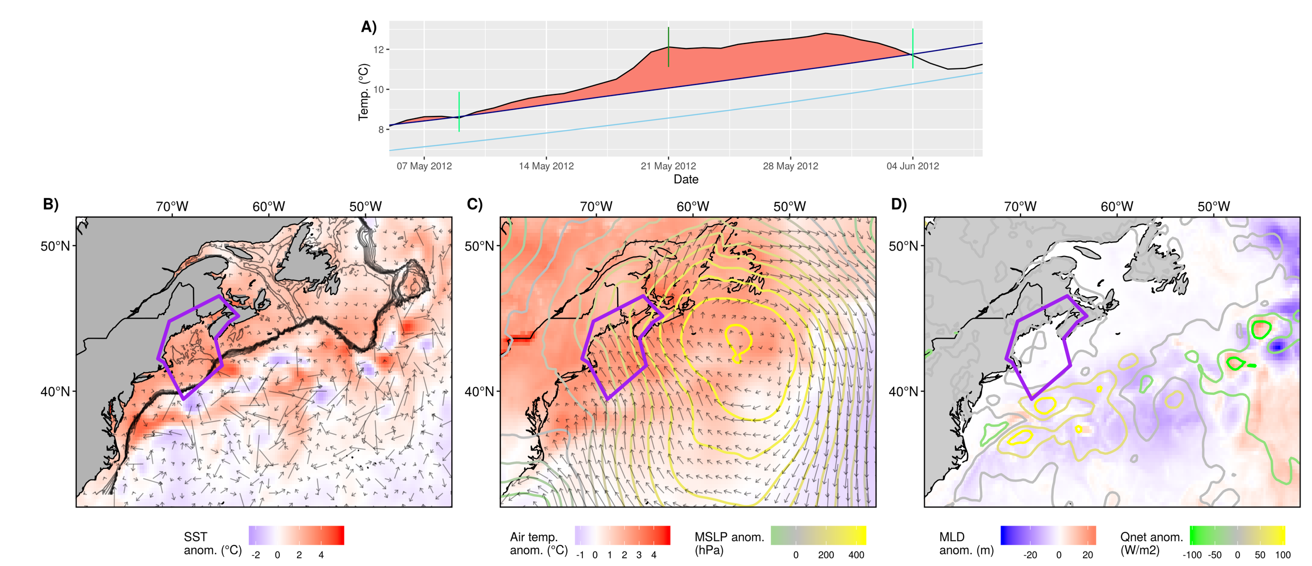

Figure 2: The information generated for a single MHW. The region of the focus event is shown as a purple polygon. A) Start and end dates of the focal MHW are marked in green. B) Mean SST and surface current anomalies during the MHW. C) Mean air temperature, MSLP, and wind anomalies. D) Mean MLD and Qnet anomalies.

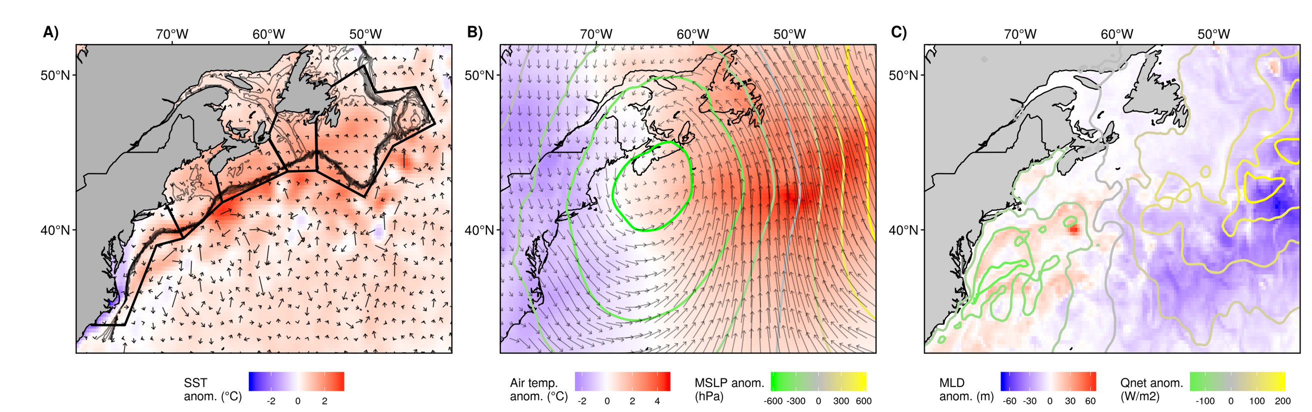

Figure 3: The mean environmental states for all MHWs clustered into node 9. A) Mean SST and surface current anomalies. Regions overlaid with black polygons and bathymetry down to 2000 m shown with black contours. B) Mean air temperature, MSLP, and wind anomalies. F) Mean MLD and Qnet anomalies.

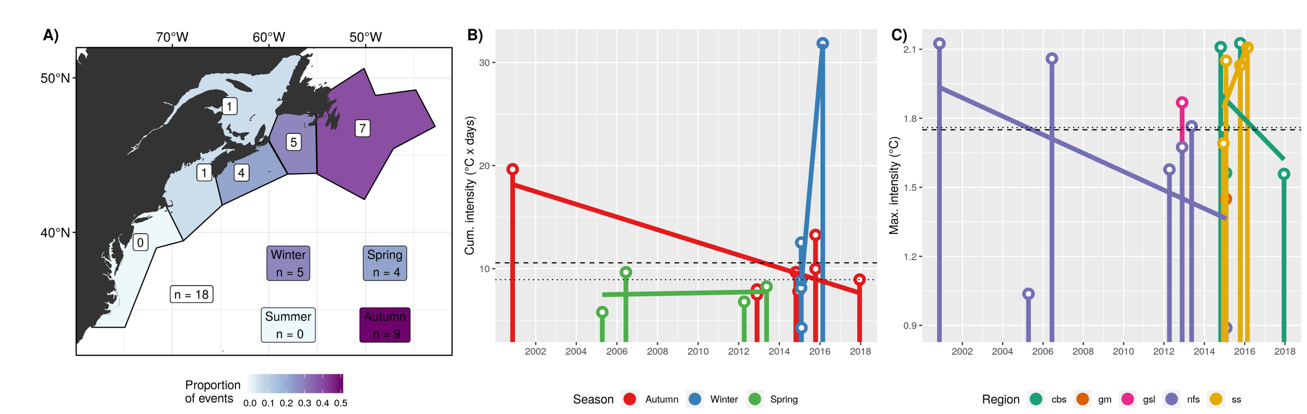

Figure 4: MHW information for node 9. A) Regions and seasons of occurrence. B) Cumulative intensity and season of occurrence for each MHW. Linear models show range of dates for MHWs and the secular trend in their cumulative intensity. C) Max intensity and region of occurrence for each MHW. Linear models show range of dates of occurrence for MHWs and secular trend in max intensity.

OCEAN FRONTIER INSTITUTE
DALHOUSIE UNIVERSITY
Woods Hole Oceanographic Institution

References

Bond, N. A., Cronin, M. F., Freeland, H., and Mantua, N. (2015). Causes and impacts of the 2014 warm anomaly in the NE Pacific. *Geophysical Research Letters* 42, 3414–3420. doi:10.1002/2015GL063306.

Deser, C., Alexander, M. A., Xie, S. P., and Phillips, A. S. (2010). Sea surface temperature variability: patterns and mechanisms. *Annual Review of Marine Science* 2, 115–143. doi:10.1146/annurev-marine-120408-151453.

Hobday, A. J., Alexander, L. V., Perkins, S. E., Smale, D. A., Straub, S. C., Oliver, E. C., et al. (2016). A hierarchical approach to defining marine heatwaves. *Progress in Oceanography* 141, 227–238. doi:10.1016/j.pocean.2015.12.014.

Hobday, A. J., Oliver, E. C., Gupta, A. S., Benthuysen, J. A., Burrows, M. T., Donat, M. G., et al. (2018). Categorizing and naming marine heatwaves. *Oceanography* 31, 162–173. doi:10.5670/oceanog.2018.205.

Olita, A., Sorgente, R., Natale, S., Gaber?ek, S., Ribotti, A., Bonanno, A., et al. (2007). Effects of the 2003 European heatwave on the Central Mediterranean Sea: surface fluxes and the dynamical response. *Ocean Science* 3, 273–289. Available at: https://hal.archives-ouvertes.fr/hal-00298334.

Oliver, E. C., Lago, V., Hobday, A. J., Holbrook, N. J., Ling, S. D., and Mundy, C. N. (2018). Marine heatwaves off eastern tasmania: Trends, interannual variability, and predictability. *Progress in oceanography* 161, 116–130. doi:10.1016/j.pocean.2018.02.007.

Richaud, B., Kwon, Y.-O., Joyce, T. M., Fratantoni, P. S., and Lentz, S. J. (2016). Surface and bottom temperature and salinity climatology along the continental shelf off the canadian and us east coasts. *Continental Shelf Research* 124, 165–181. doi:10.1016/j.csr.2016.06.005.

Schlegel, R. W., Oliver, E. C., Perkins-Kirkpatrick, S., Kruger, A., and Smit, A. J. (2017). Predominant atmospheric and oceanic patterns during coastal marine heatwaves. *Frontiers in Marine Science* 4, 323. doi:10.3389/fmars.2017.00323.