Primary Drivers of Marine Heatwaves in the Northwest Atlantic

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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. Garrabou et al., 2009; 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 averaged together into one time series.
- MHWs were calculated from these 6 averaged 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.
- In node 9 we see a clear Nor'easter pattern (Figure 3C).
- The centre of the high SST anomaly (Figure 3B) has a deepening MLD and negative downward heat flux (Figure 3D).
- Most MHWs occurred northwest of the centre of the SST anomaly (Figure 3A) due to the downward heat flux and shoaling MLD (Figure 3D).
- None of these events occurred in Summer (Figure 3G), and most events occurred on the Newfoundland Shelf (Figure 3H).

Conclusions

- The nodes tell three main stories:
  - Warm Gulf Stream + air pushing up from south along coast.
  - Warm air sitting over entire coast.
  - Warm air being pushed over the Atlantic from the South/Southeast onto the coast.
- Overall the most intense MHWs occur during Autumn/Winter when they match patterns that are normally seen in Summer.
- The SOM technique functions better in the Northwest Atlantic if the Labrador Sea is excluded from the study area.

The most intense MHWs occur during Autumn/Winter when large scale atmospheric patterns look like Summer MHW conditions

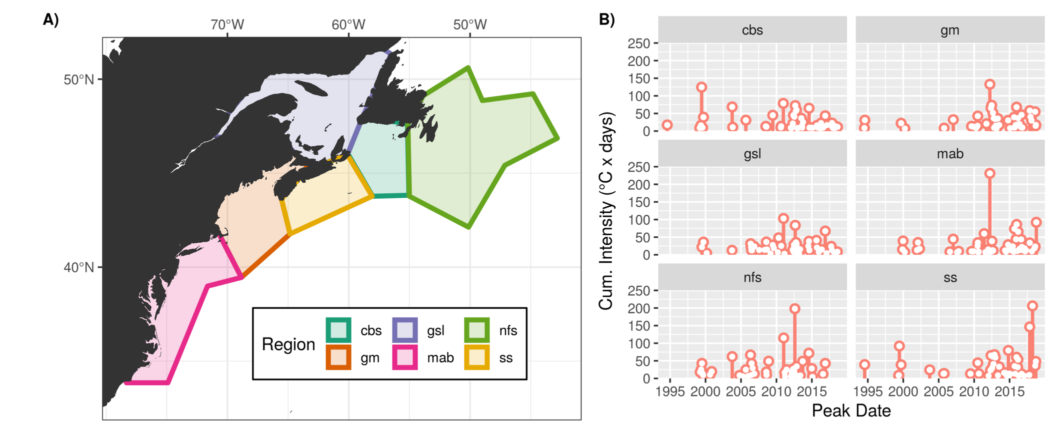

Figure 1: The regions of the study area and the marine heatwaves (MHWs) detected within them. The region abbreviations are: gm = Gulf of Maine, gls = Gulf of St. Lawrence, ls = Labrador Shelf, mab = Mid-Atlantic Bight, nfs = Newfoundland Shelf, ss = Scotian Shelf. A) The regions of the coast were divided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

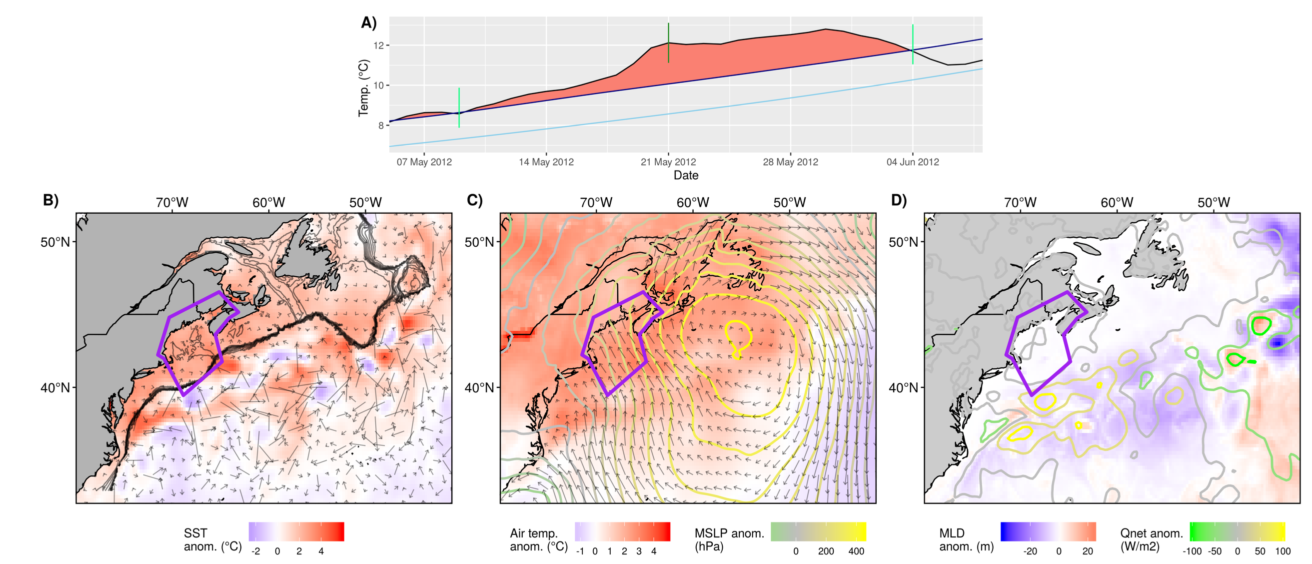

Figure 2: An overview of the information contained in one MHW data packet. The region of the focus event is shown as purple polygon. A) The focal MHW shown in salmon; the start and end dates of the focal event are marked in light green while the peak date is marked in dark green. B) The SST and surface current anomalies during the MHW. C) The wind stress, mean sea level pressure, and air temperature anomalies. D) The net positive downward heat flux mixed layer depth anomalies.

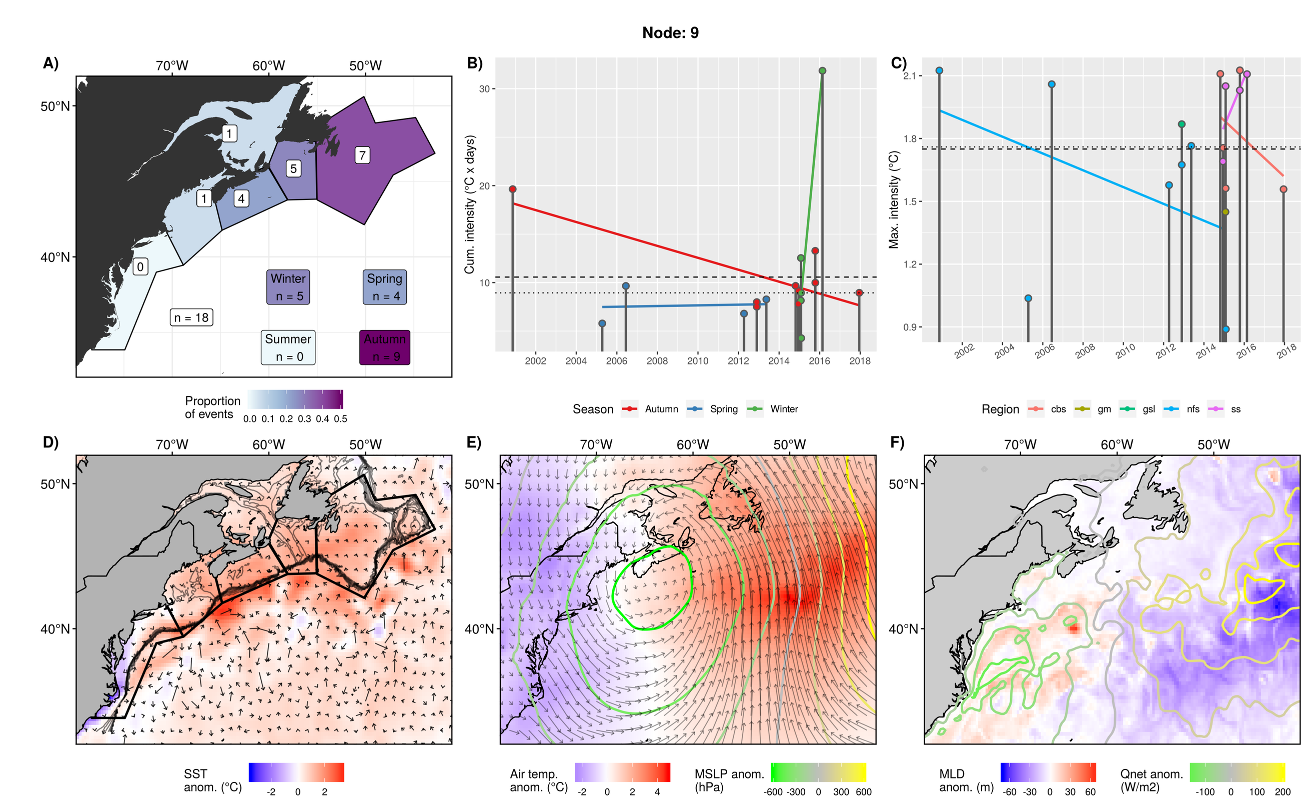

Figure 3: Summary visuals for the results from node 9. The environmental states for all MHWs clustered into this node were meaned to create the images in panels D - F. A) Regions and seasons of occurrence for MHWs in node 9. B) The cumulative intensity and season of occurrence for each MHW. Linear model shows range of dates of occurrence for MHWs and the secular trend in their cumulative intensity. C) The max intensity and region of occurrence for each MHW. Linear model shows range of dates of occurrence for MHWs and secular trend in max intensity. D) Mean SST and surface current anomalies. Region polygons overlaid in black and bathymetry down to 2000 m shown with black contours. E) Mean air temperature, MSLP, and surface wind anomalies. F) Mean mixed layer depth and net positive downware heat flux anomalies.

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