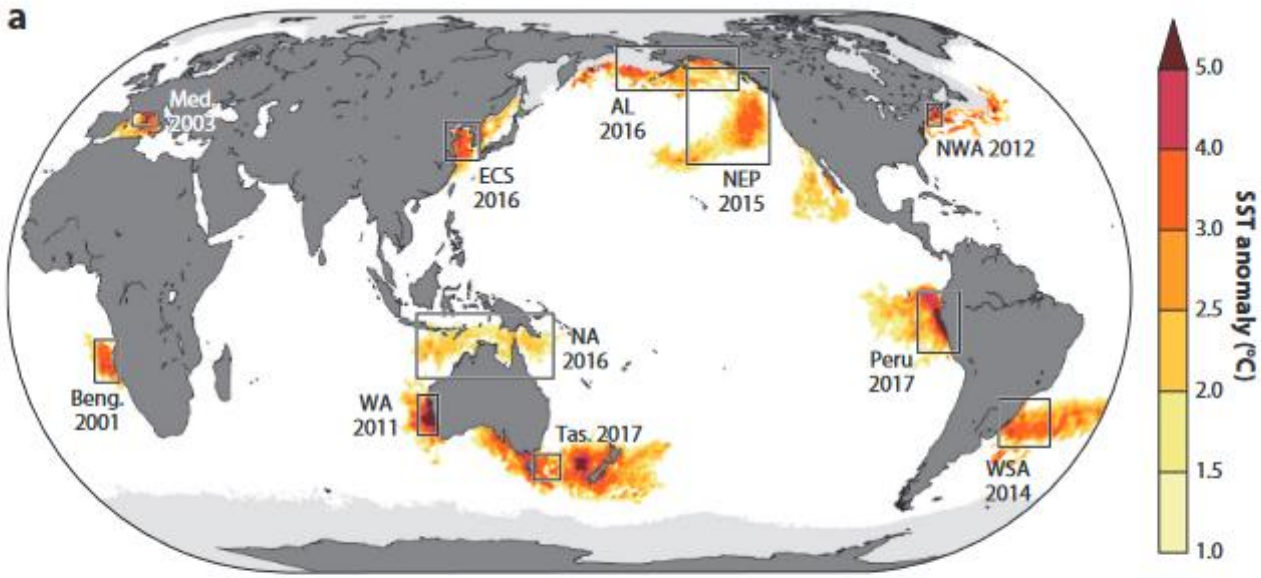
VIMS | William & Mary
Virginia Institute of Marine Science

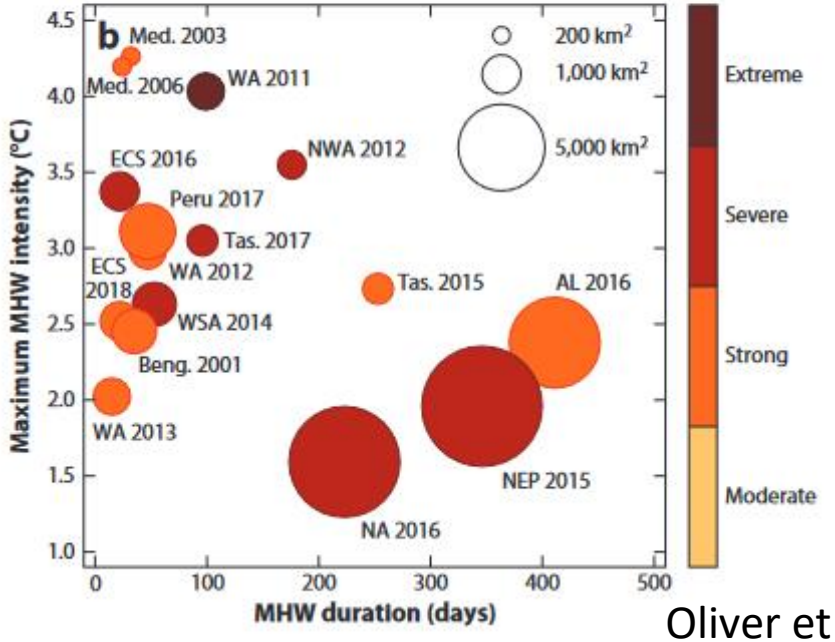
Impact of Marine Heatwaves on Subsurface Hydrography and Dissolved Oxygen in the Chesapeake Bay

NATHAN SHUNK; PIERO L.F. MAZZINI; CASSIA PIANCA

Marine Heat Waves (MHWs): Global Ocean

- Range in Intensity, Duration, and Spatial Scale
- Global Long-Term Trends
  - Increasing Frequency, Intensity, Duration, and Spatial Extent
- Drivers of SST Anomalies
  - Advection
  - Air-Sea Interactions





Oliver et al., 2021

Marine Heat Waves: Impacts

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- WA 2011: Sea Grass die off (Strydom et al., 2020)
- NEP 2015 & NWA 2012: Fishery Declines & Biogeography shifts (Cheung & Froelicher, 2020; Mills et al., 2013)
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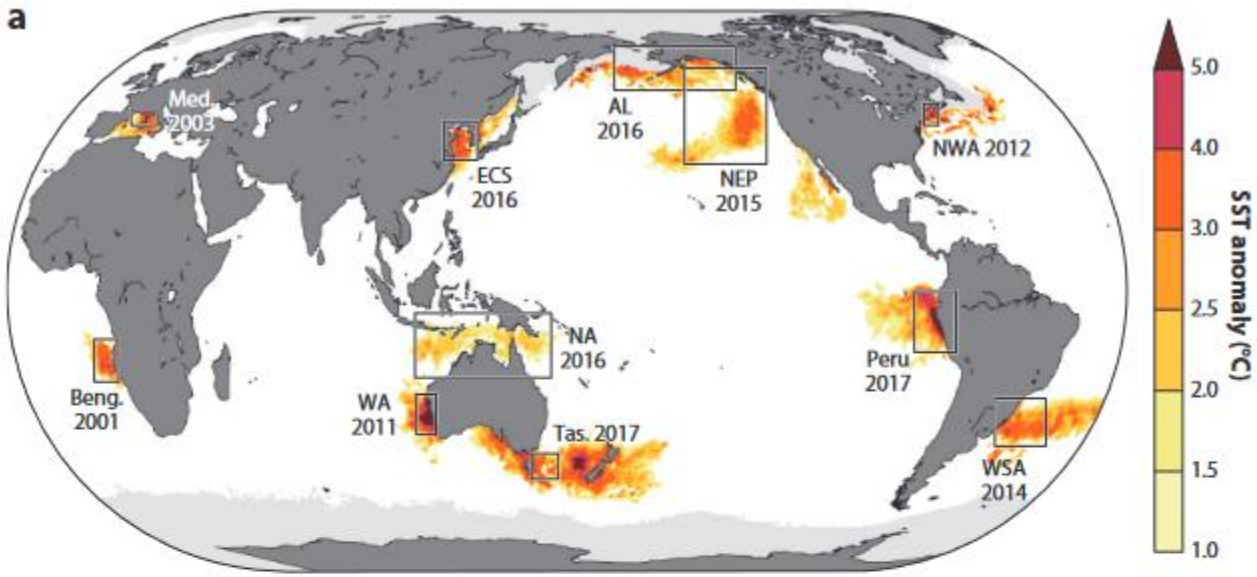

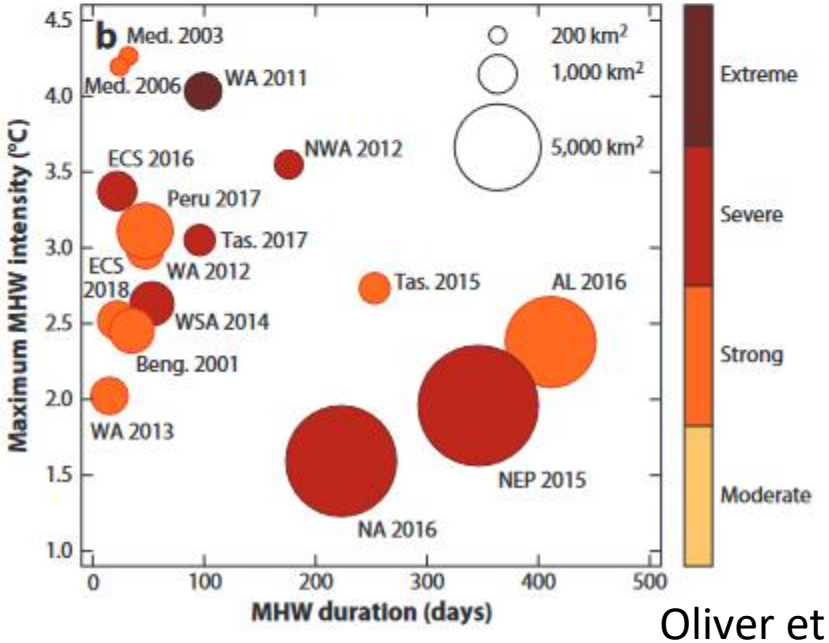

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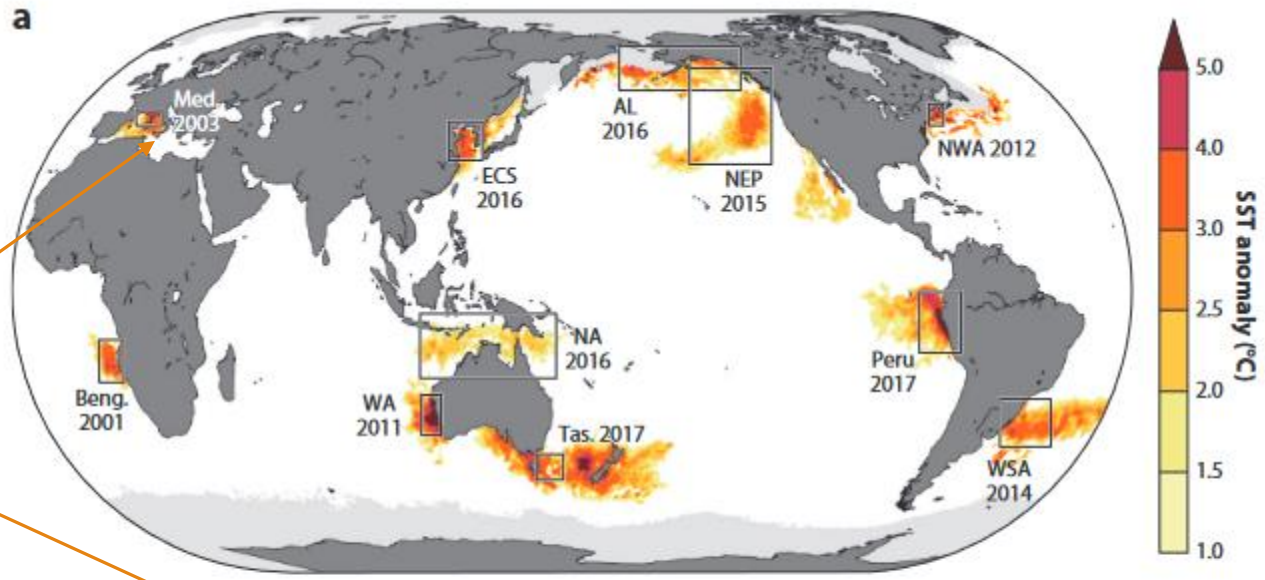

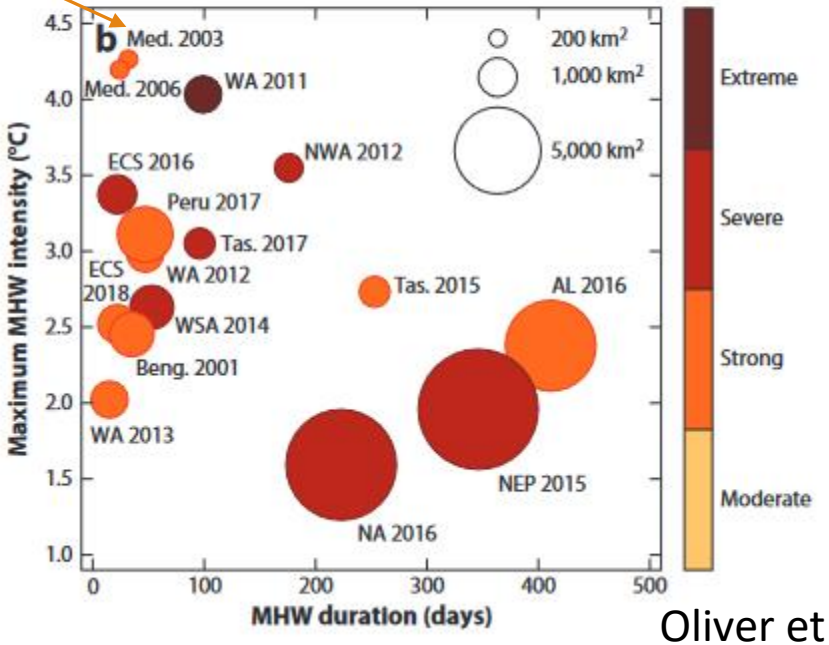

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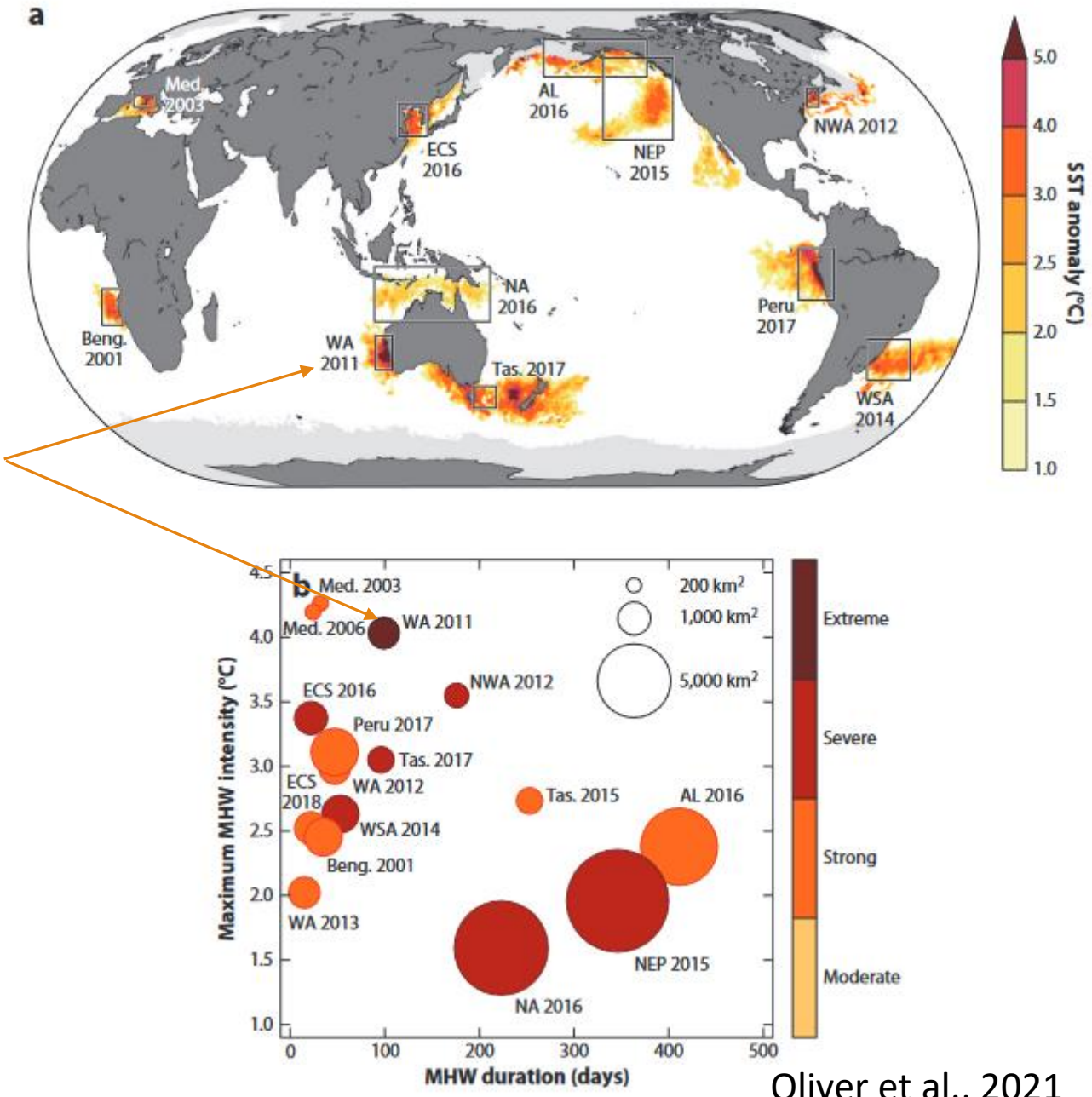

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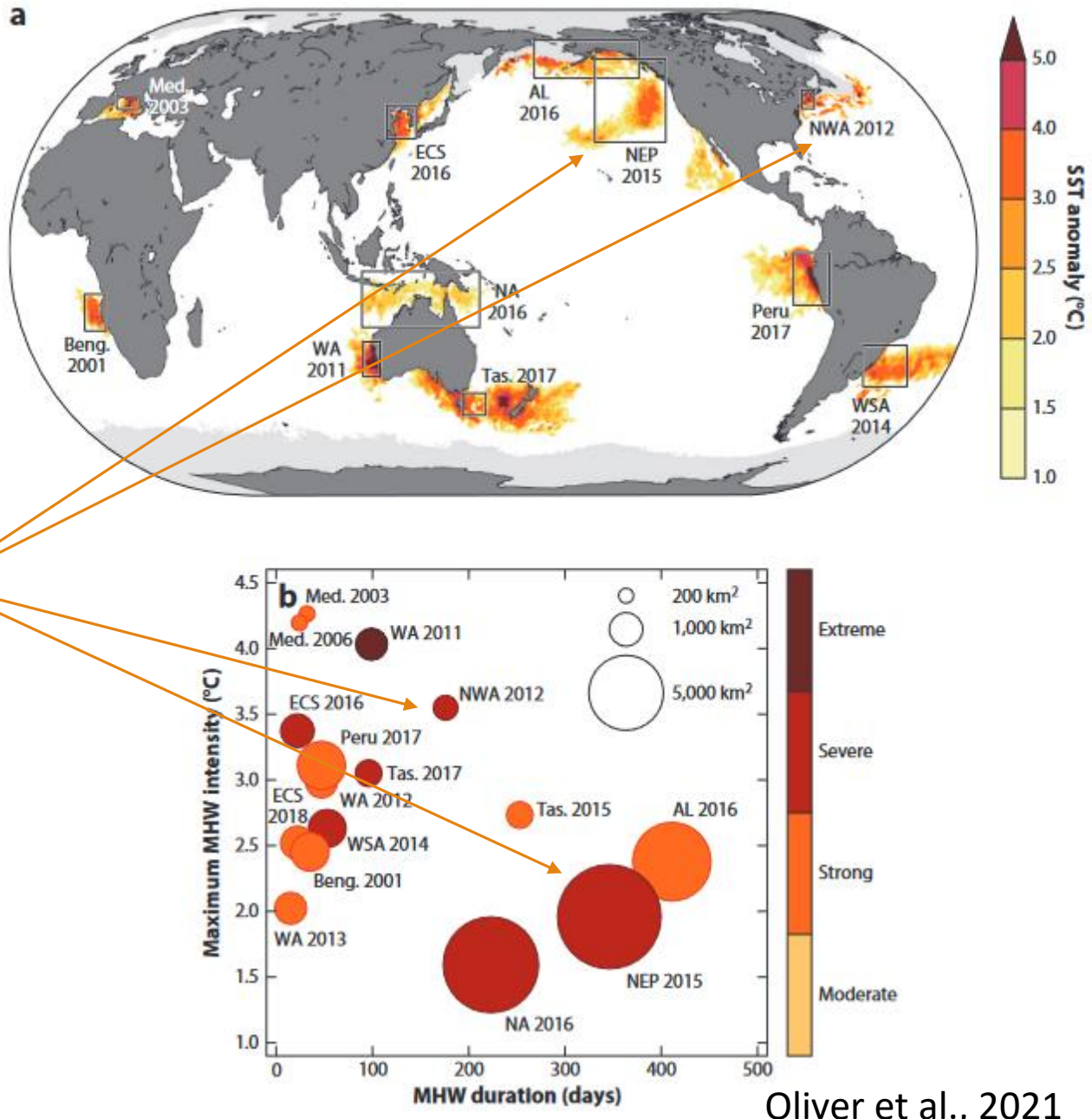

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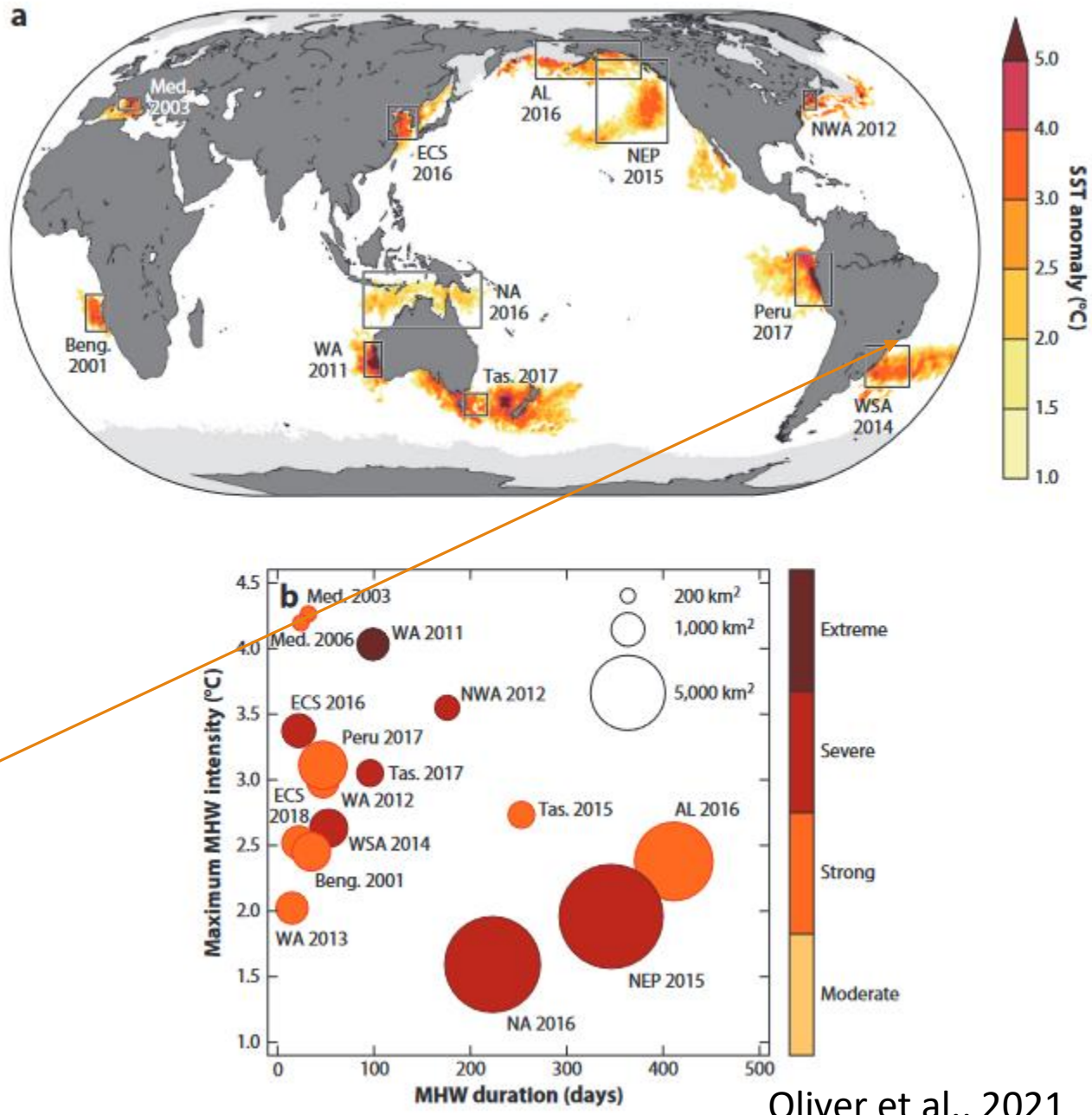
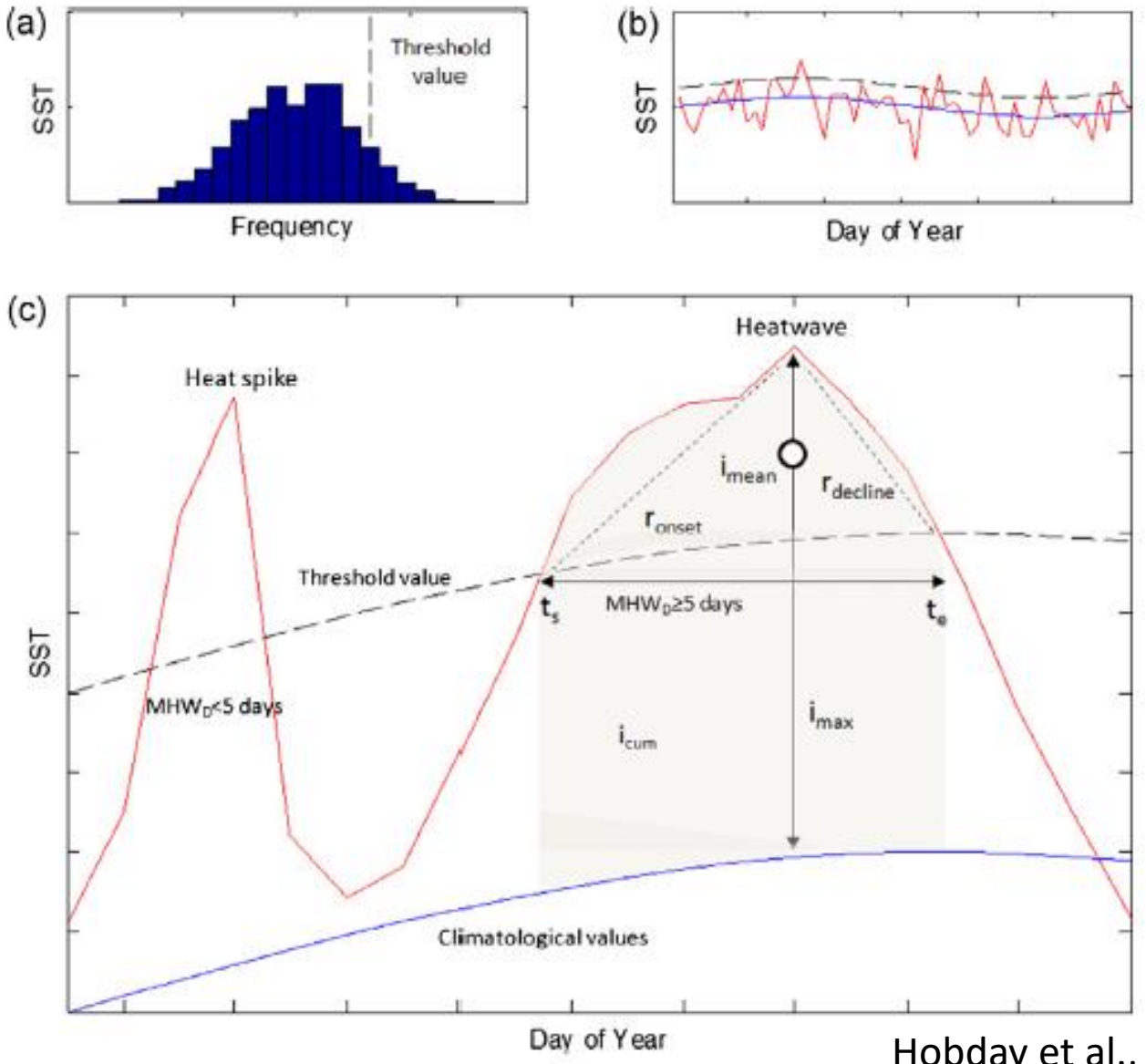


Oliver et al., 2021

MHW Definition (Hobday et al., 2016)

"A **discrete prolonged anomalously warm** water event in a particular location"

- **Anomalously warm**:
  90th percentile above climatology
- **Prolonged**:
  Period of at least 5 days
- **Discrete**:
  2-day gap between two 5-day intervals



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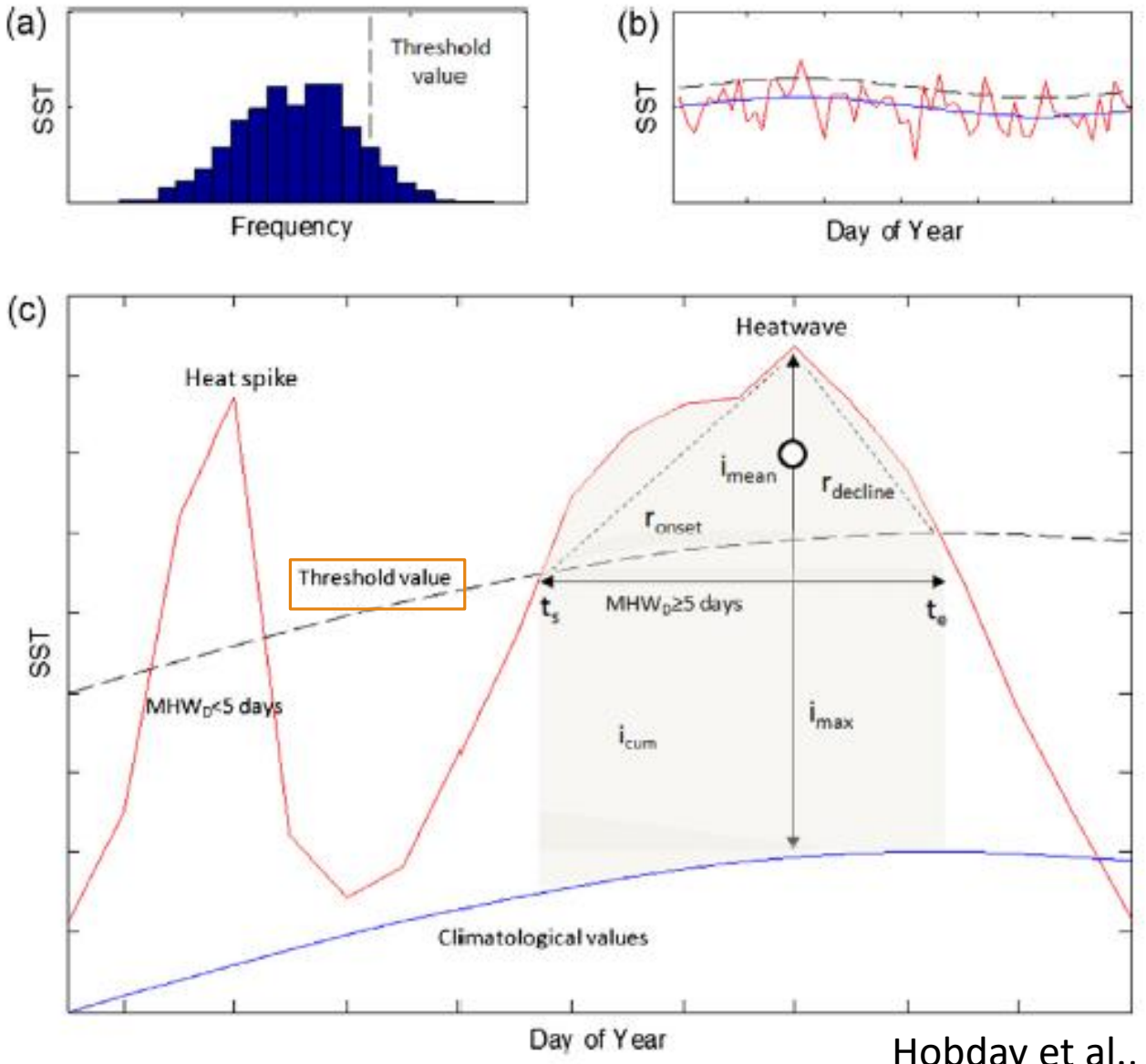

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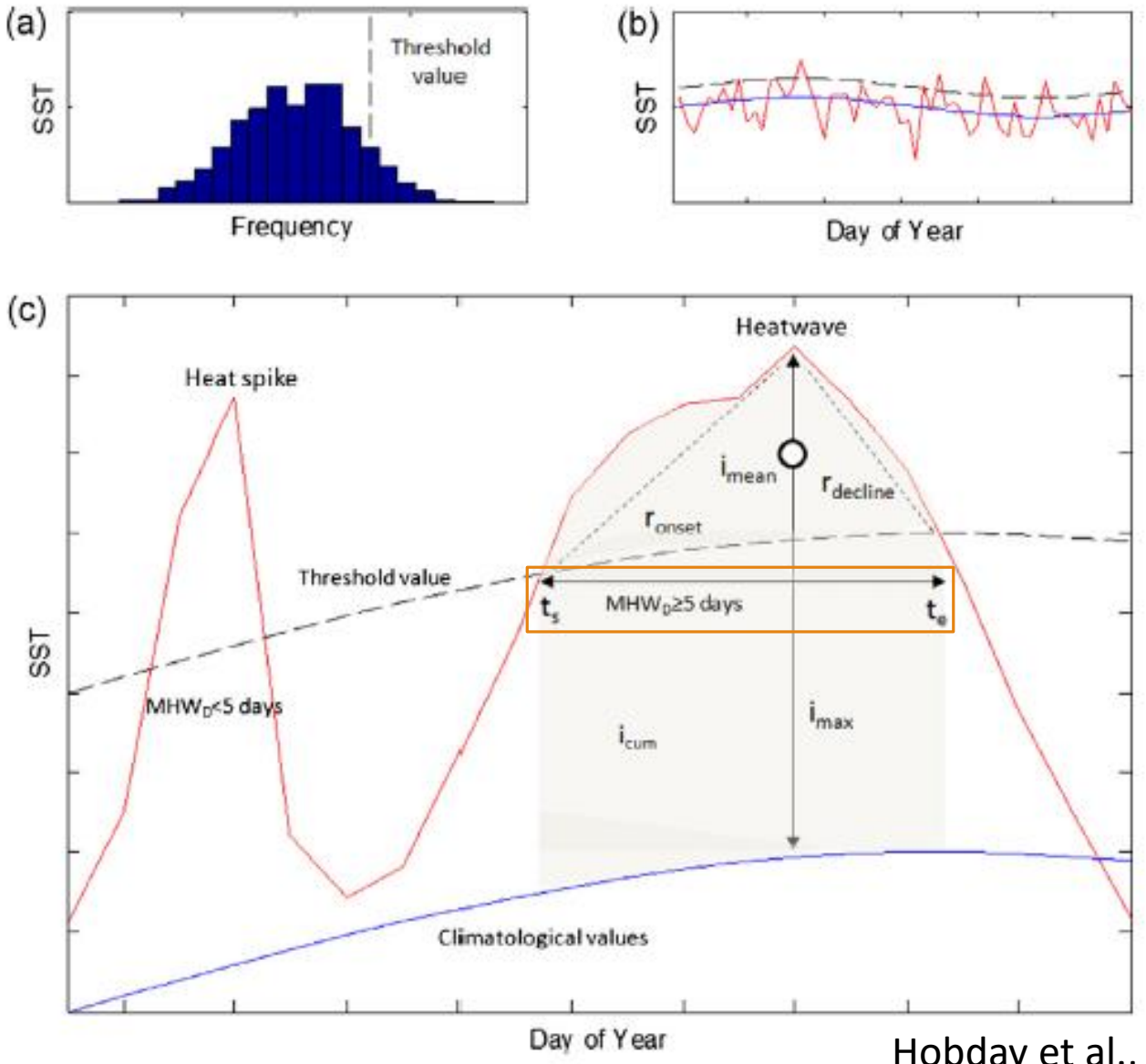

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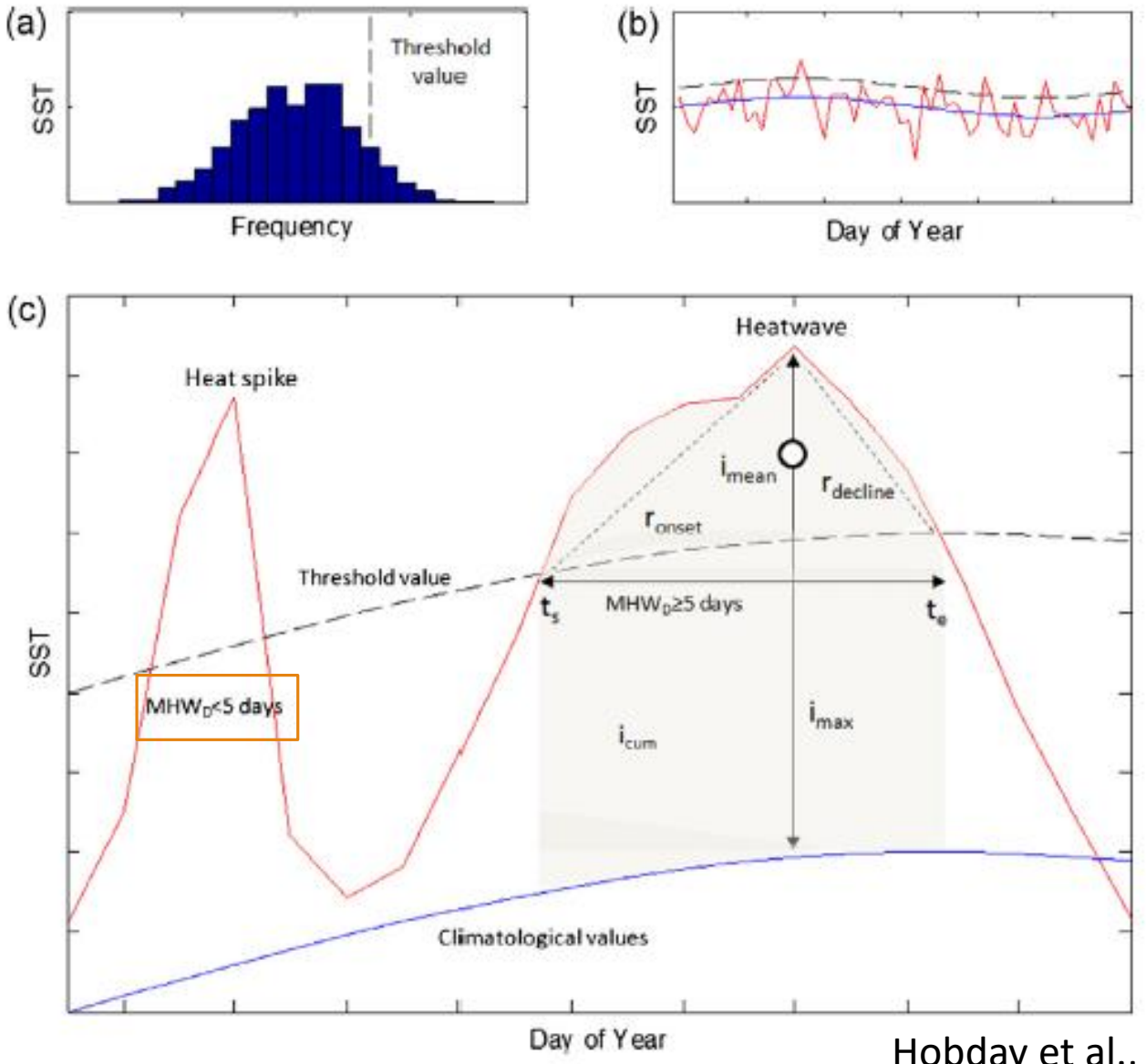

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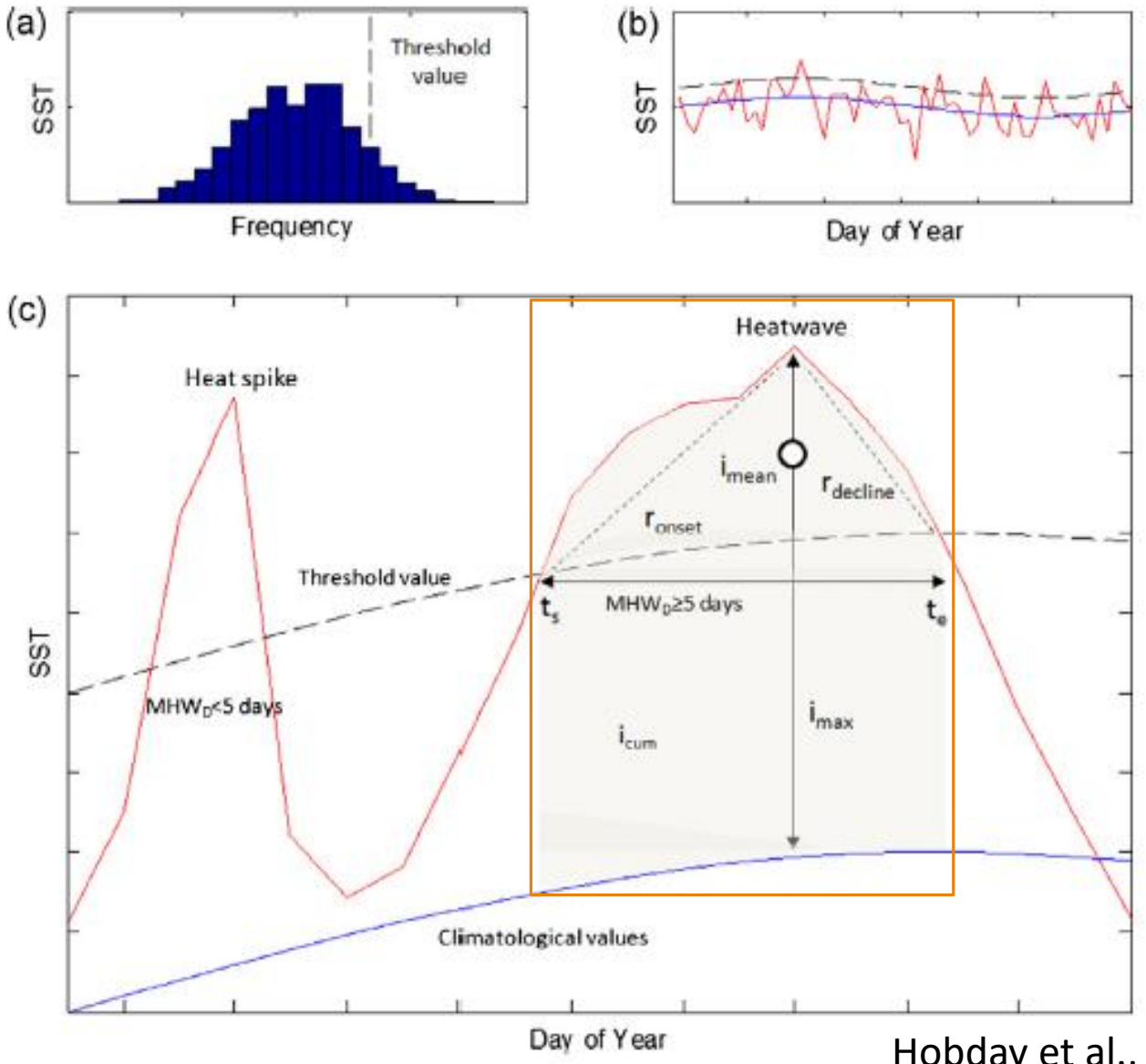

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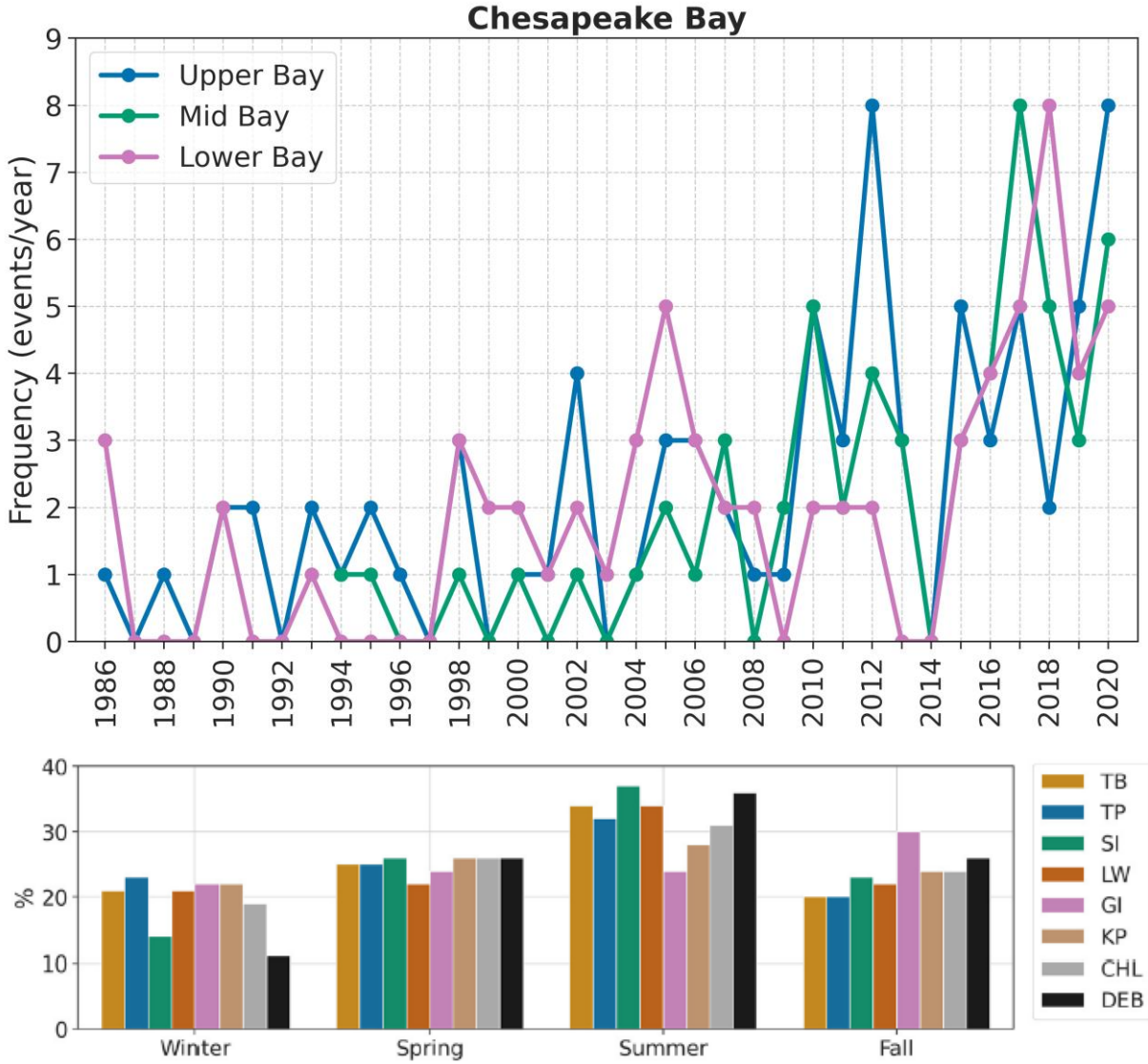
Marine Heatwaves in the Bay

- Increasing Frequency of Events
- Greater Percentage in Summer
- Increasing Cumulative Intensity
- Co-occurrence Across the Bay



Mazzini & Pianca, 2022

Research Objectives

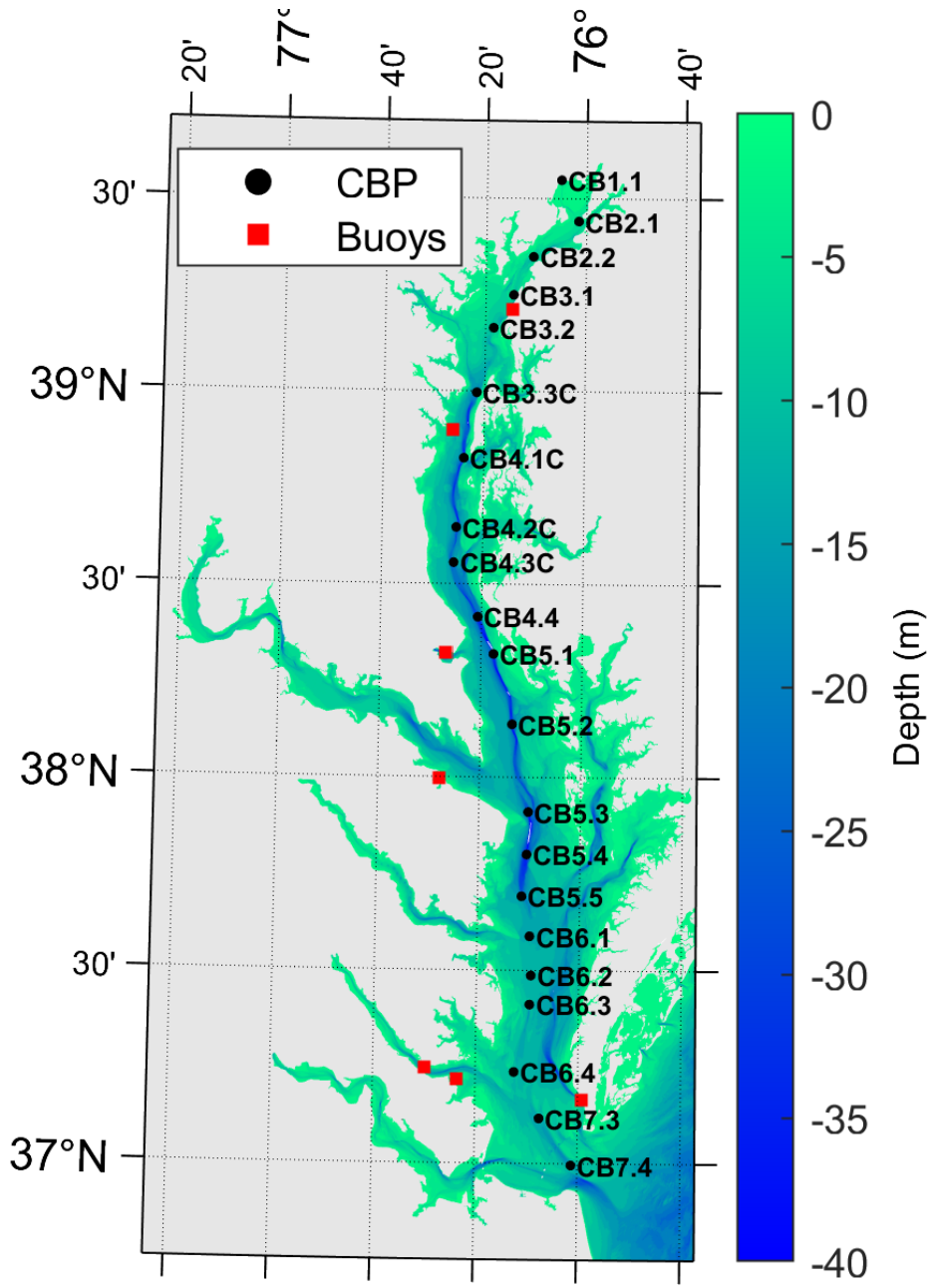
Characterize the **spatial distribution** of MHWs along the Chesapeake Bay estuarine salinity gradient, and their **seasonal variability.**

Investigate **anomalies** in hydrographic and water quality parameters associated with MHWs, specifically **salinity** and **dissolved oxygen** content.

Analyze how **mixed layer depth** and **vertical stratification** may **impact distribution of temperature anomalies** in the water column during MHW events.

Methods:
Data Availability

- **Data:** 21 Stations; 1986-2021
  - Continuous Monitoring Stations (NOAA, NERR, VIMS)
    (Mazzini & Pianca, 2022)
  - Chesapeake Bay Program Cruise Profiles
    - Temperature, Salinity, Dissolved Oxygen
    - Density Calculated Using Gibbs-SeaWater Toolbox TEOS-10
      (McDougall & Baker, 2011)
    - Profiles Linearly Interpolated



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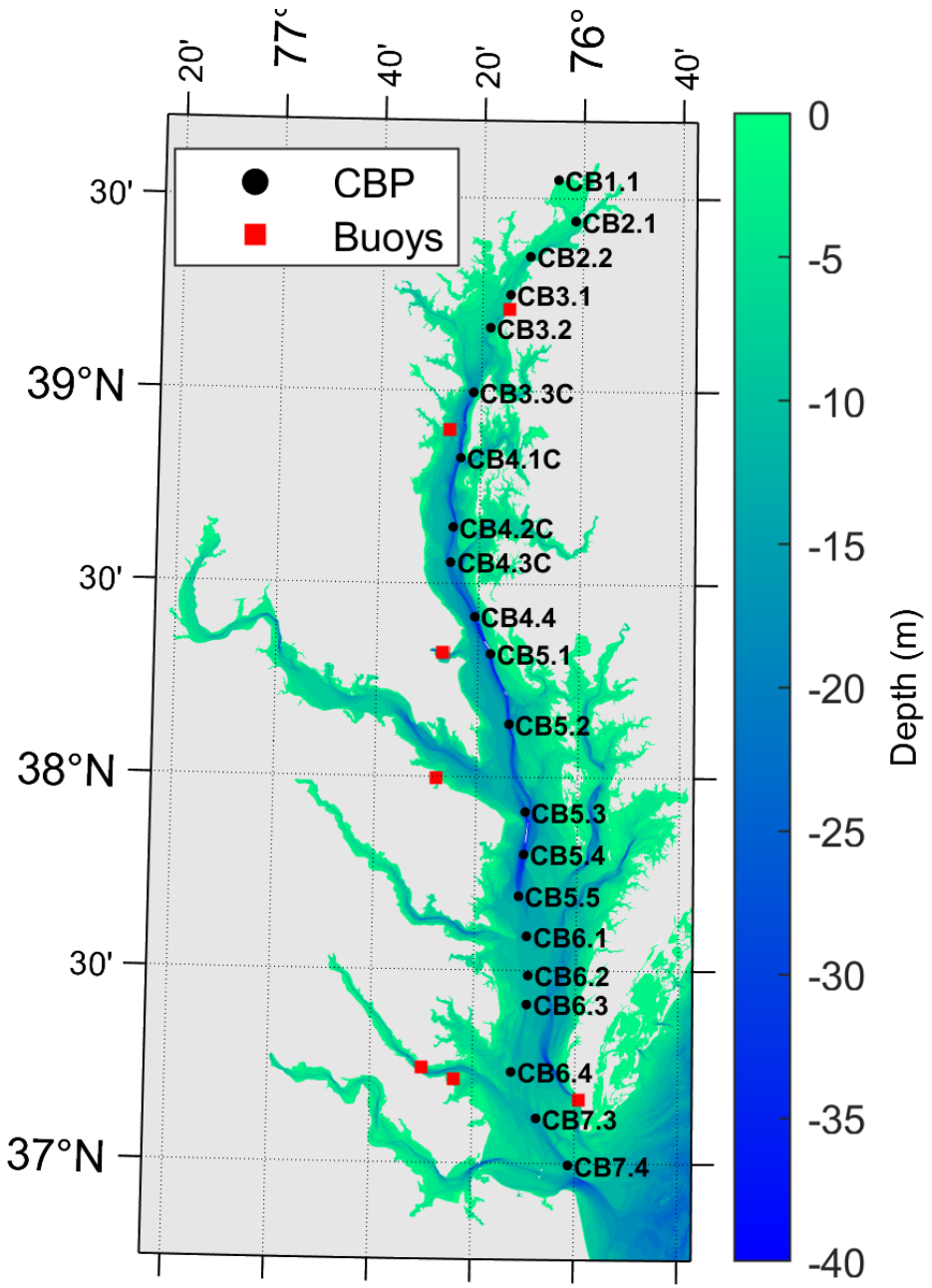
      (McDougall & Baker, 2011)
    - Profiles Linearly Interpolated
- MHW Identification
  - Spatially Averaged Time Series
  - m_mhw (Zhao & Marin, 2019)
  - Climatology Not Smoothed
  - 5 Day Duration



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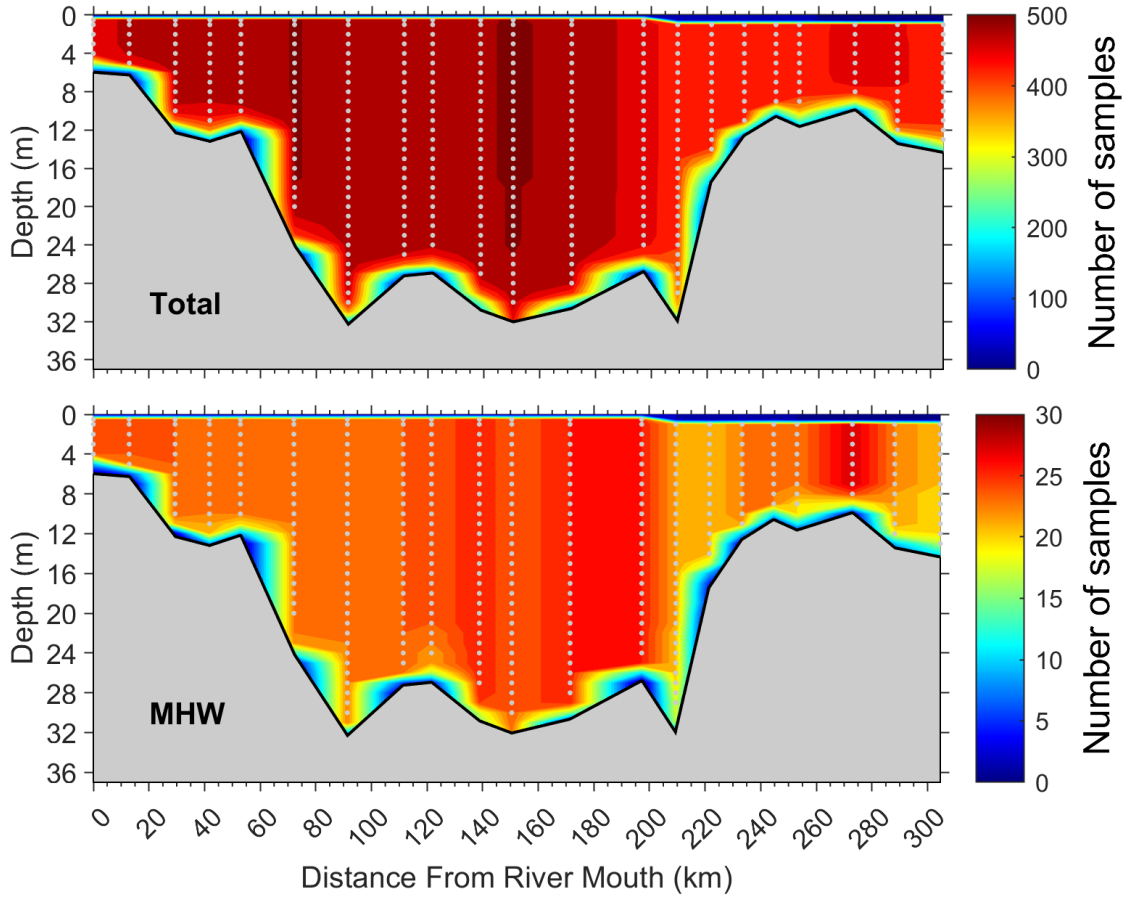

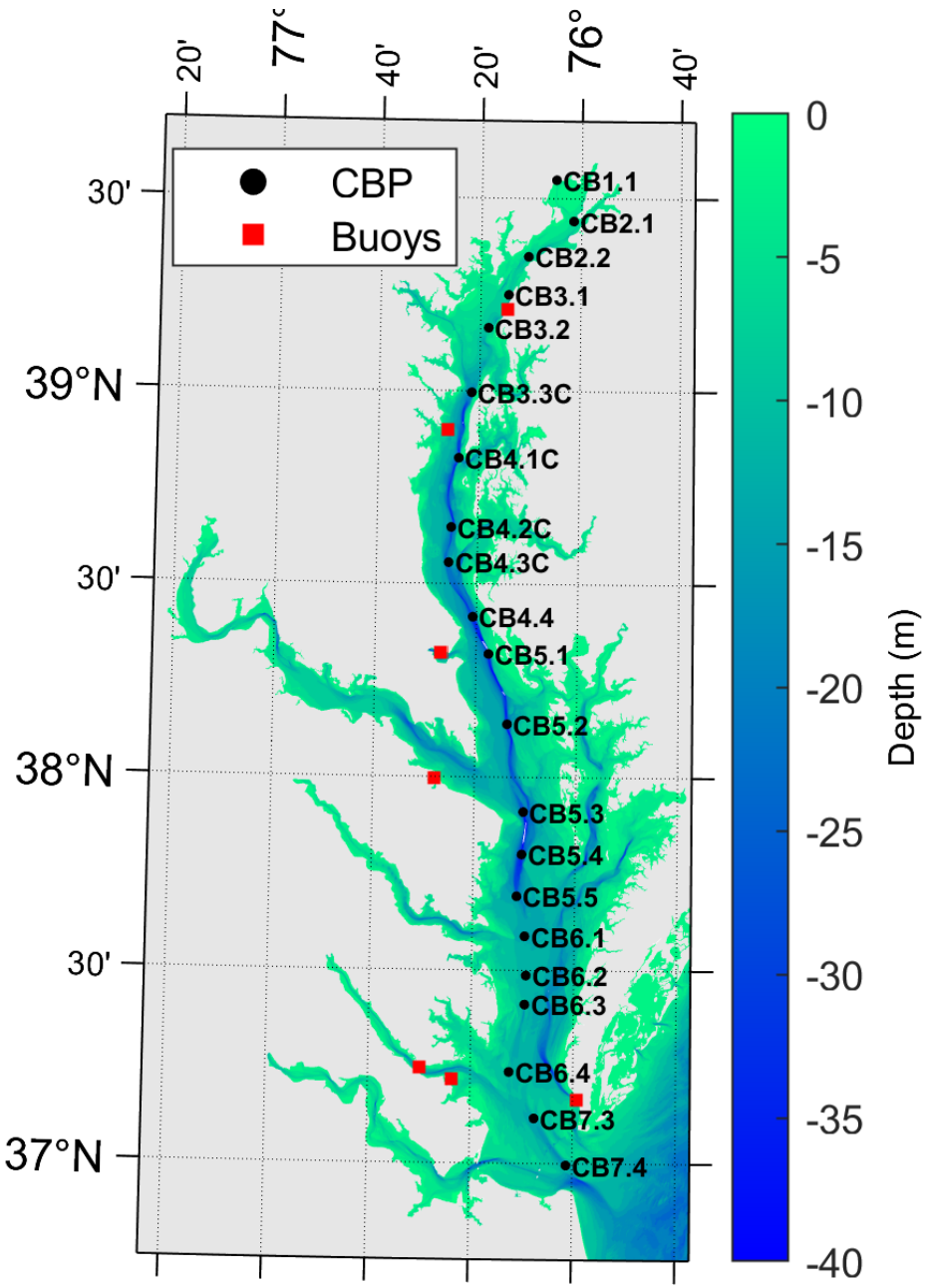

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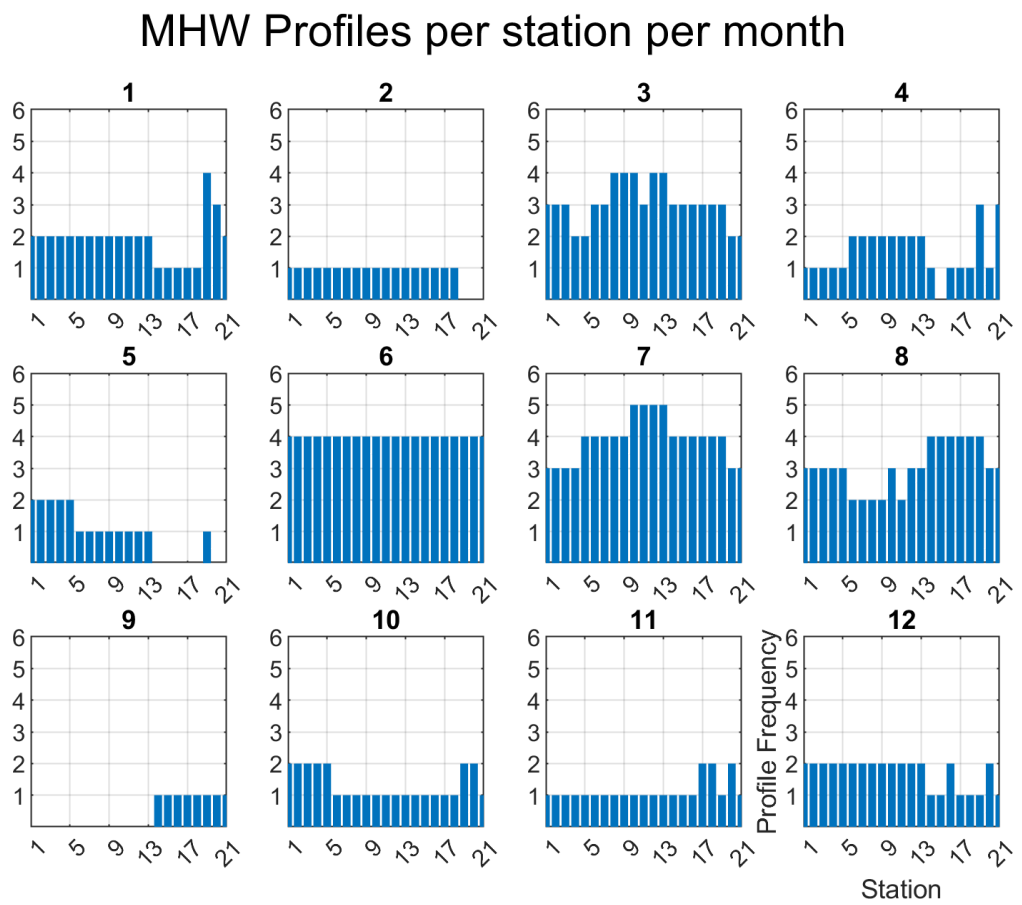
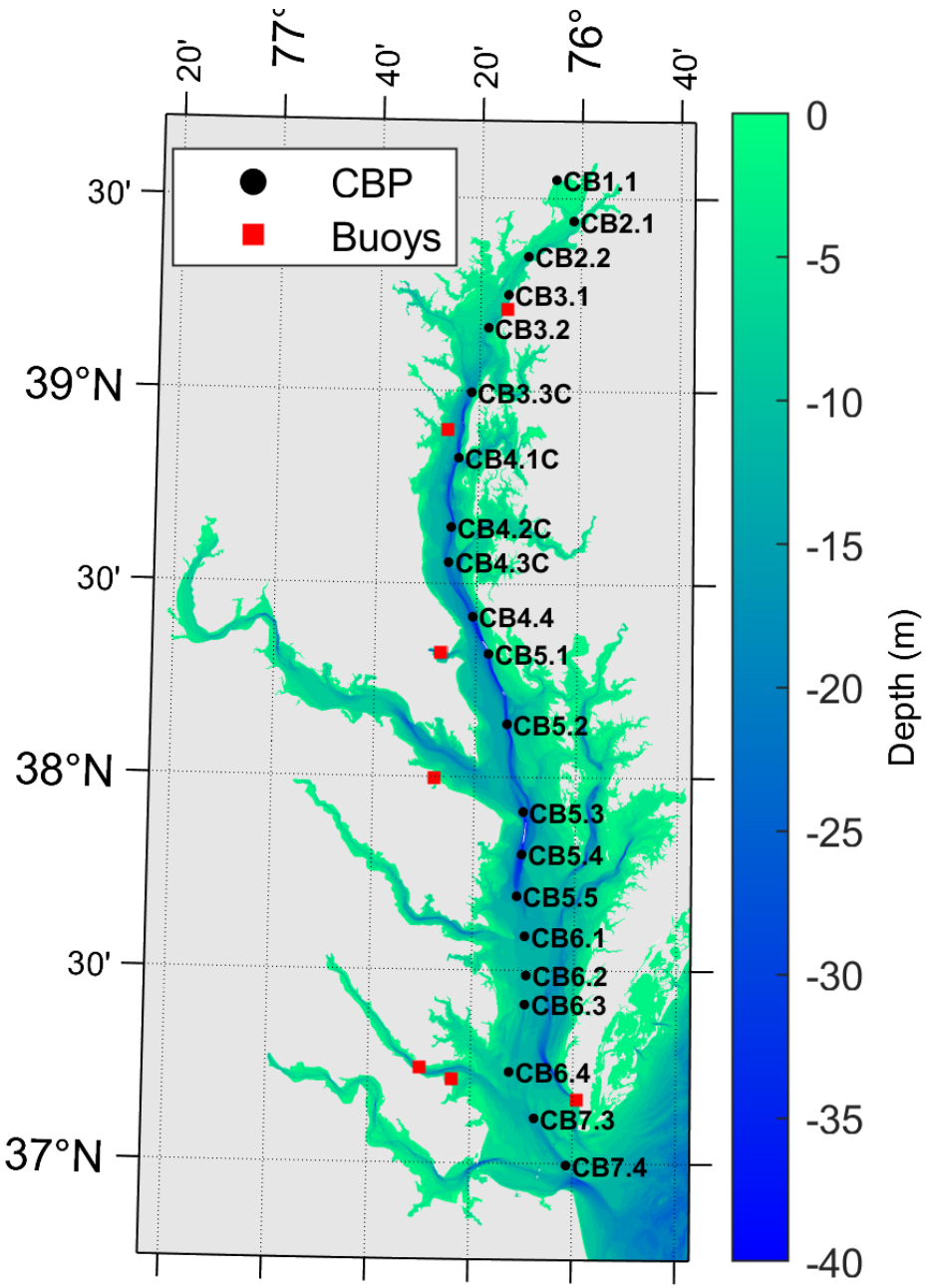
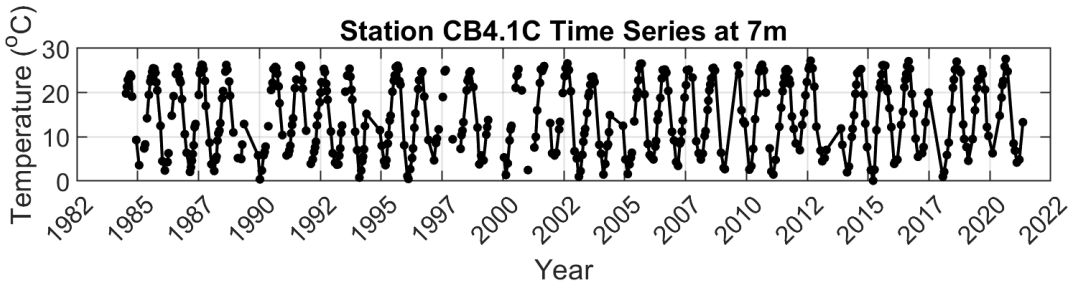




Methods: Climatology

For Temperature & Salinity

- Daily Climatology at each grid point
- Produce Daily Anomaly profiles



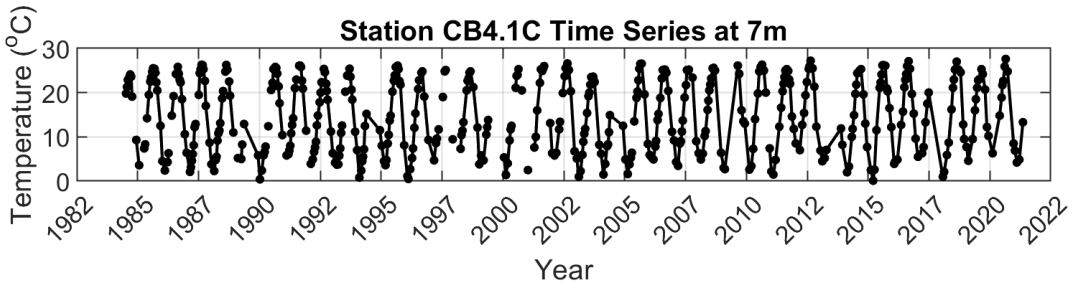
Methods: Climatology

$$y(t) = \mu + \sum \beta_m \sin(m\pi f_0 t) + \beta_m \cos(m\pi f_0 t)$$

f_0 = 1/365.2422; $m = 2,4,6$

For Temperature & Salinity

- Daily Climatology at each grid point
- Produce Daily Anomaly profiles
- LSM Harmonic Analysis: 3 Harmonics



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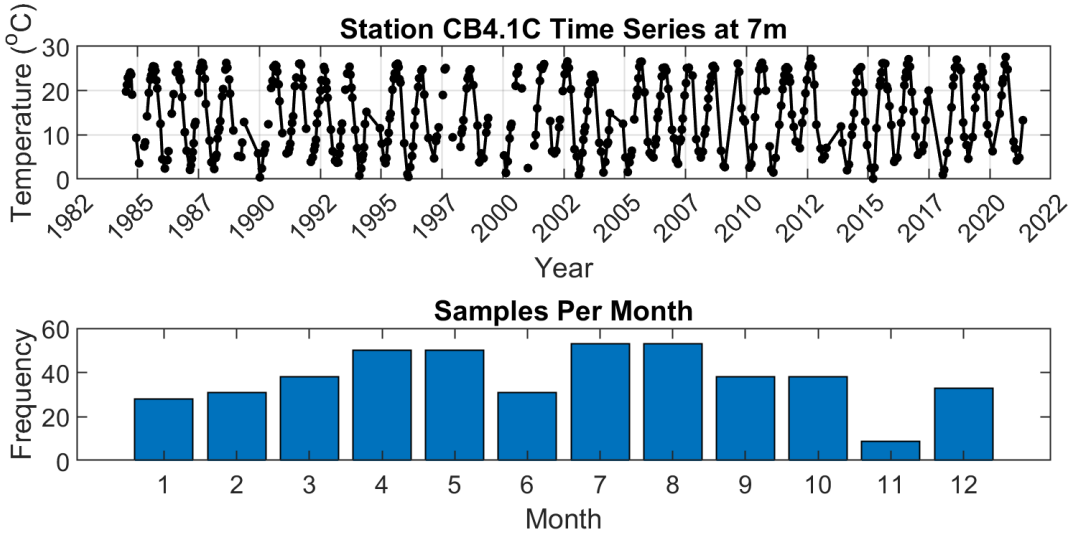

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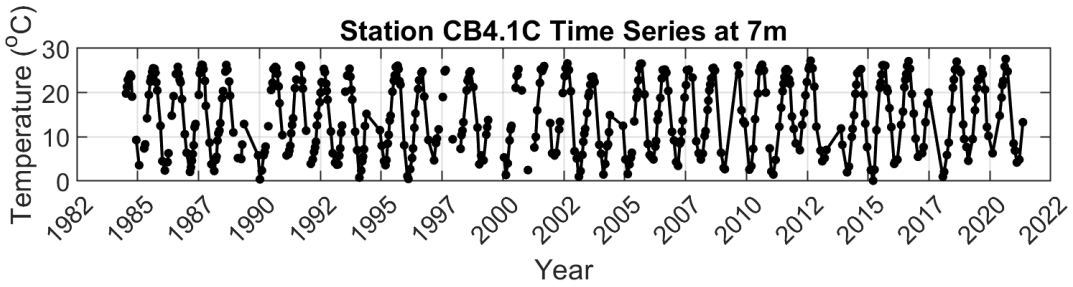
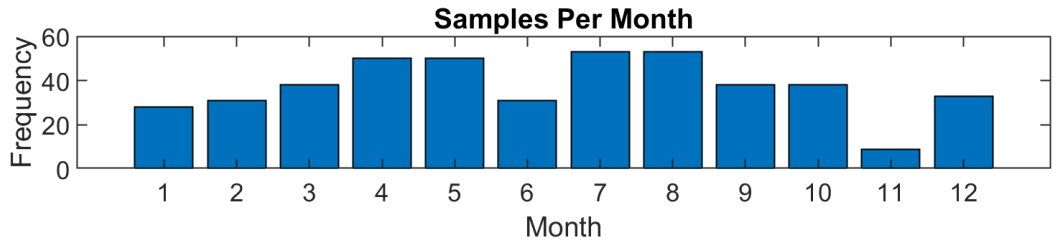
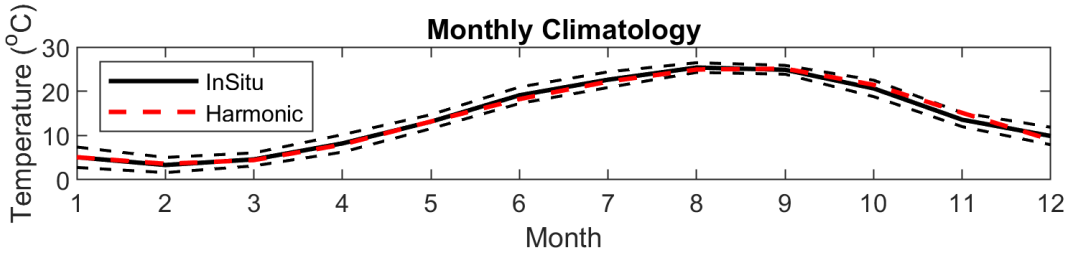
For Temperature & Salinity

- Daily Climatology at each grid point
- Produce Daily Anomaly profiles
- LSM Harmonic Analysis: 3 Harmonics
- Validated against Monthly Climatology







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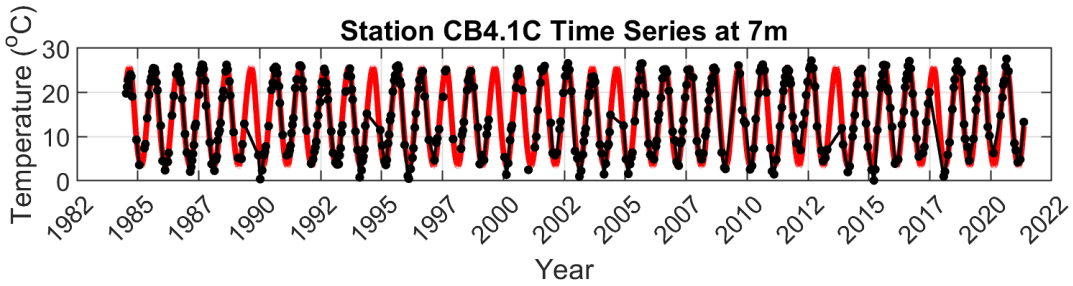

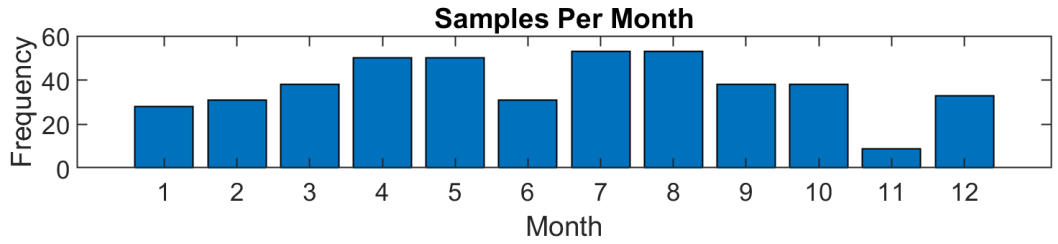

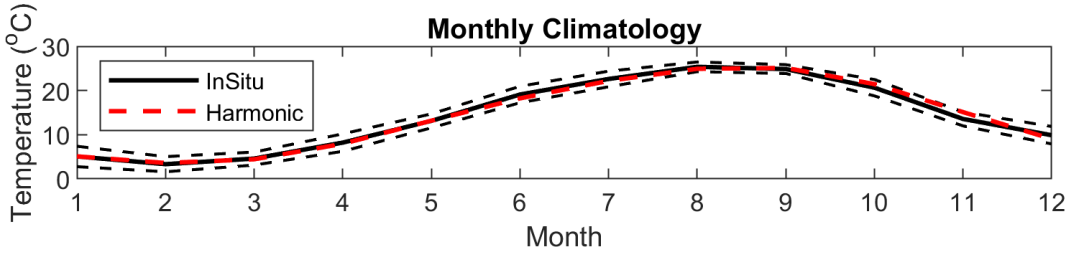

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For Temperature & Salinity

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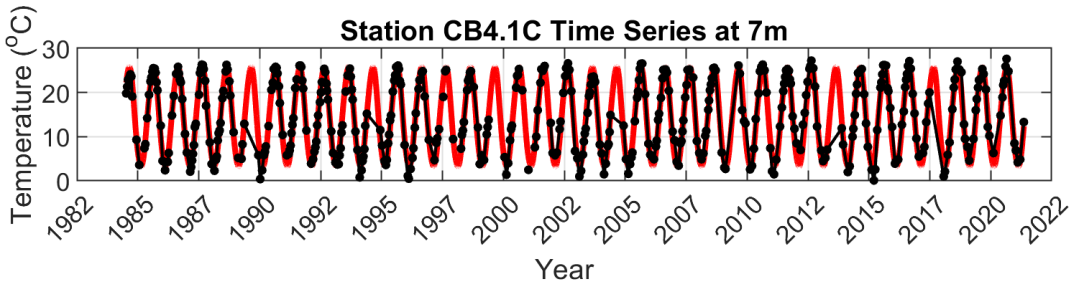
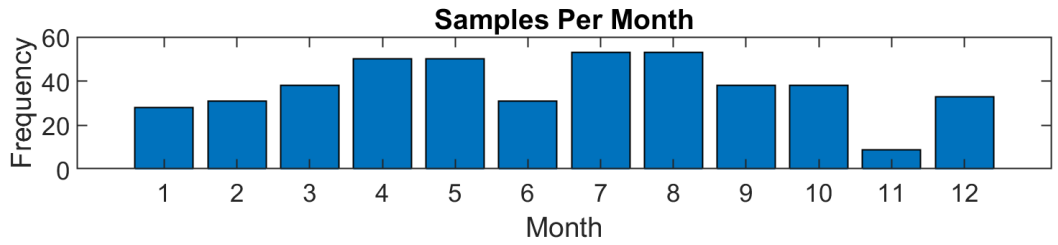
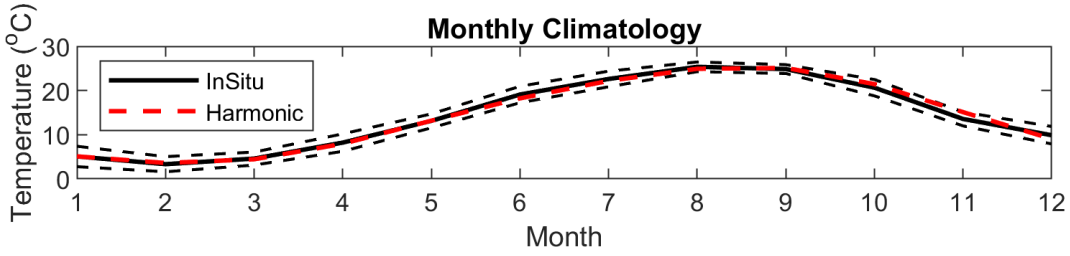
For Dissolved Oxygen

- Monthly Average Climatology



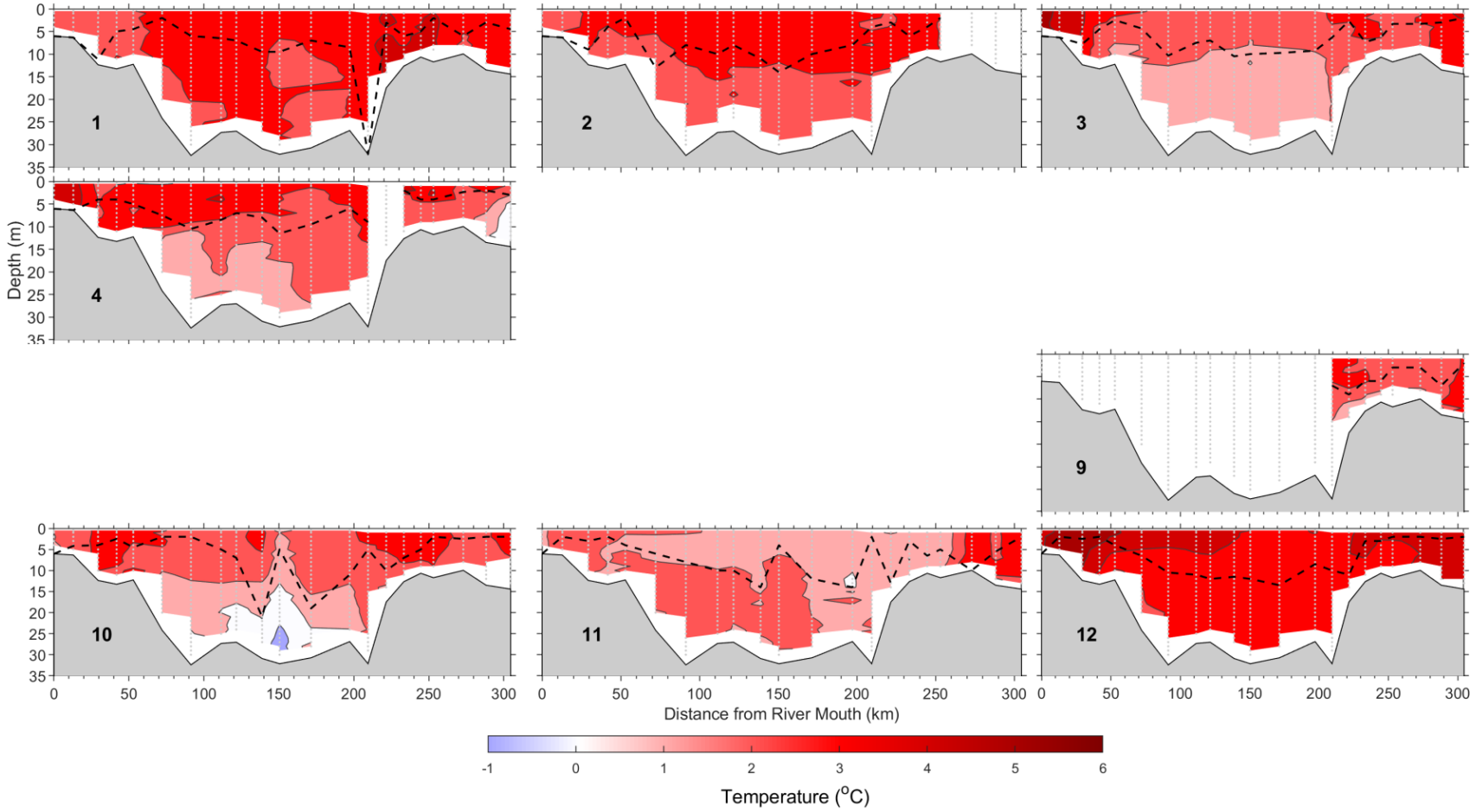




Results:
Monthly Mean MHW Temperature Anomalies

Mixed Layer Depth

Used Irby et al. (2016) Definition



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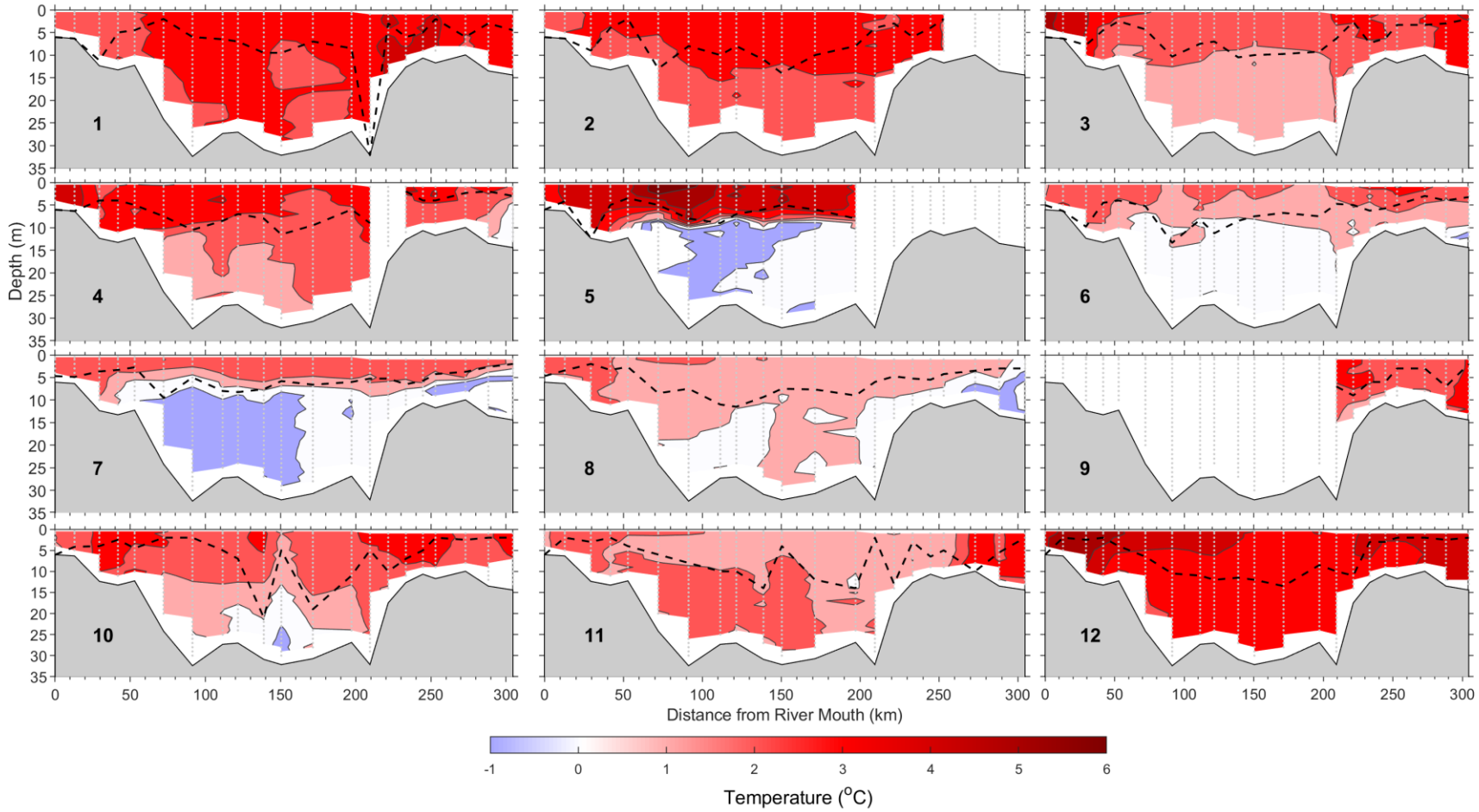

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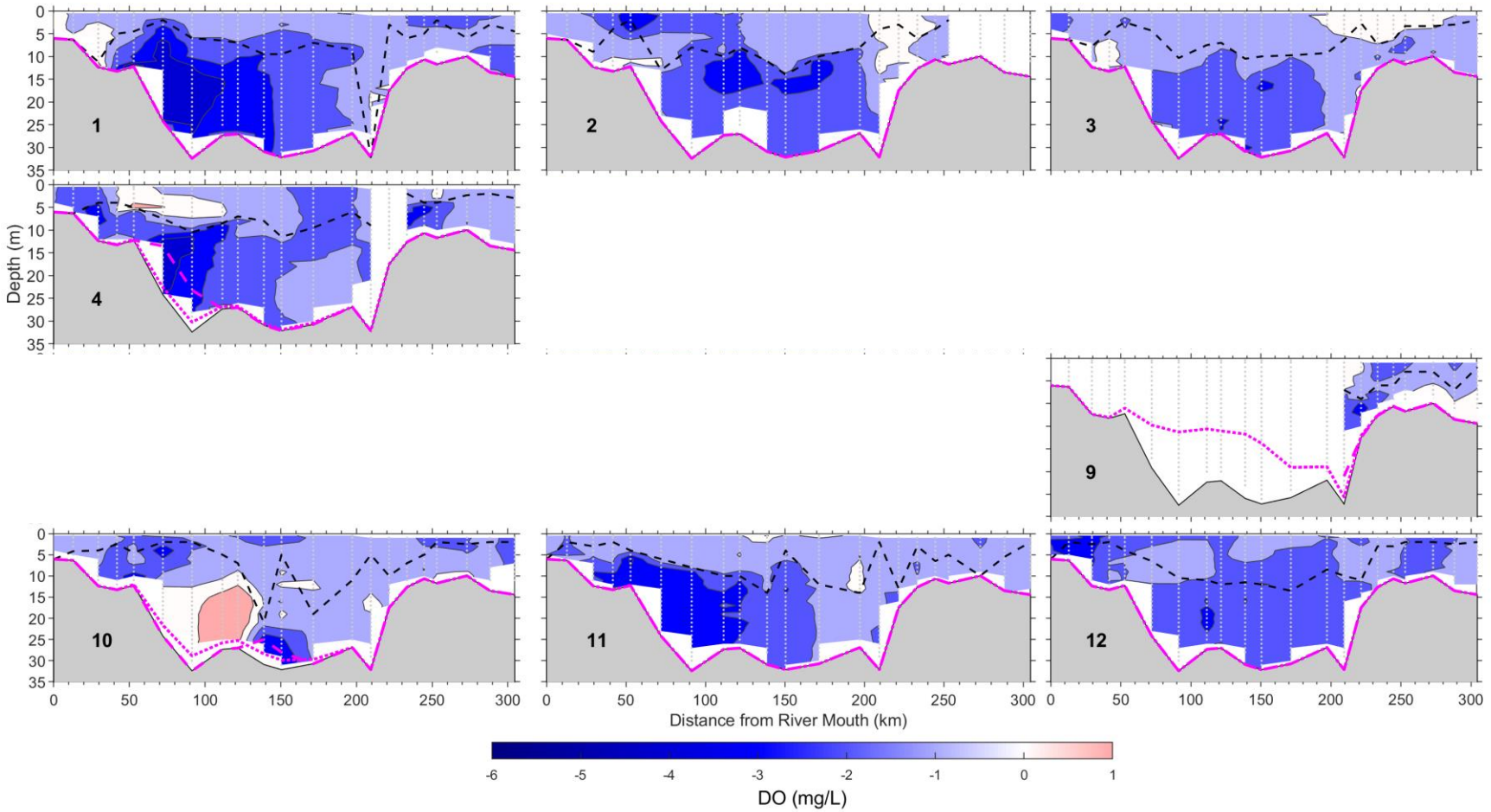

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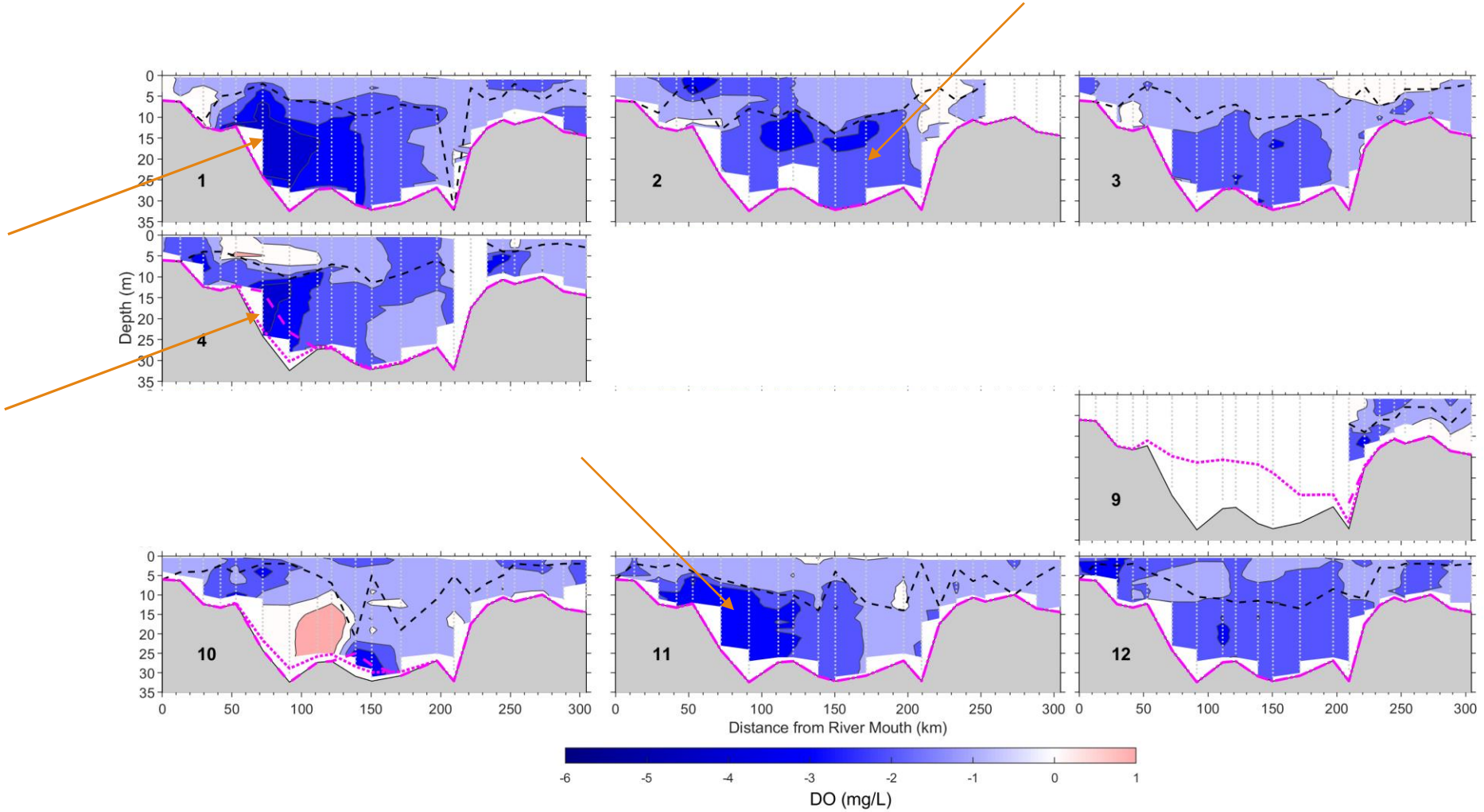

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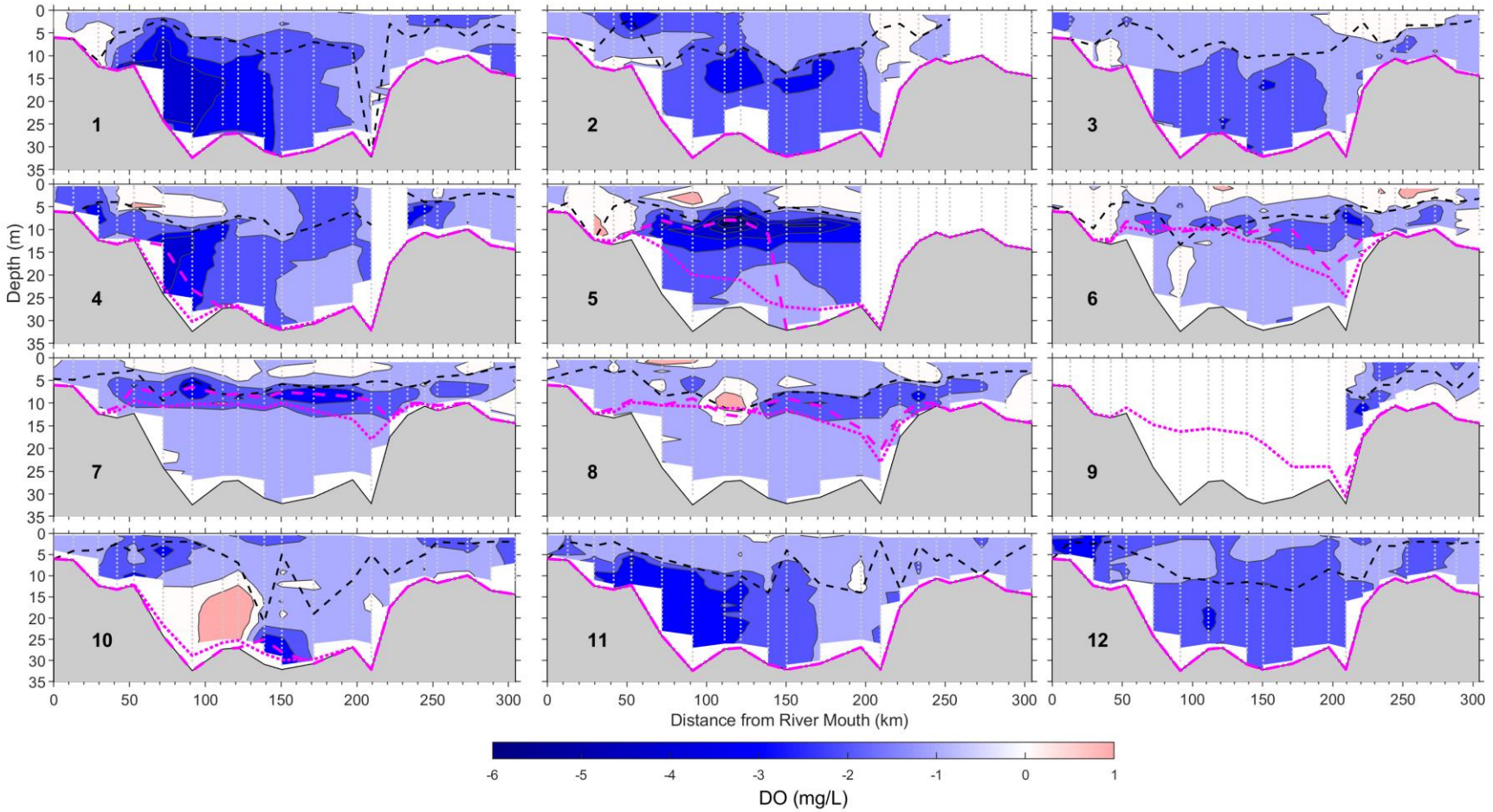

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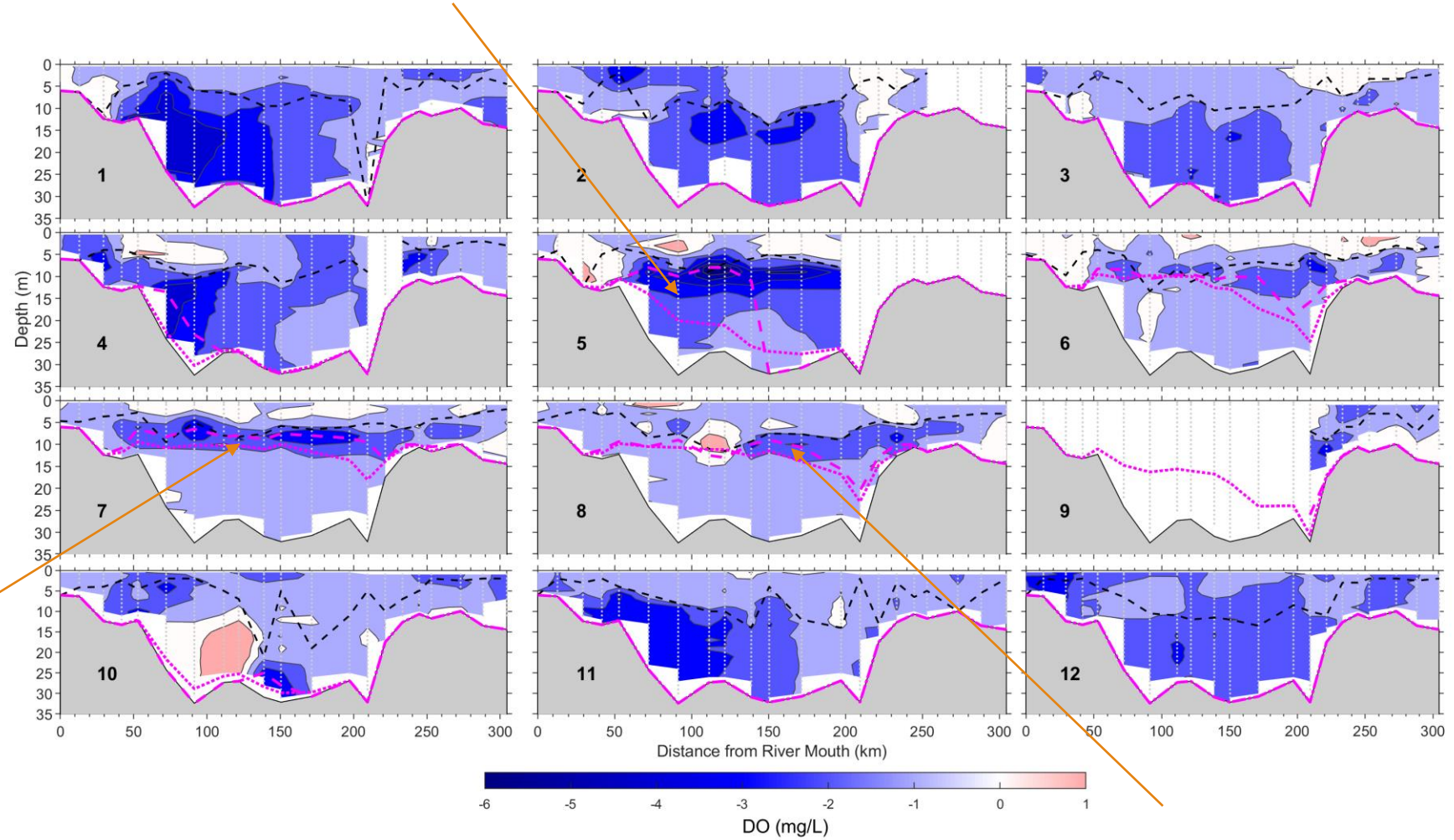
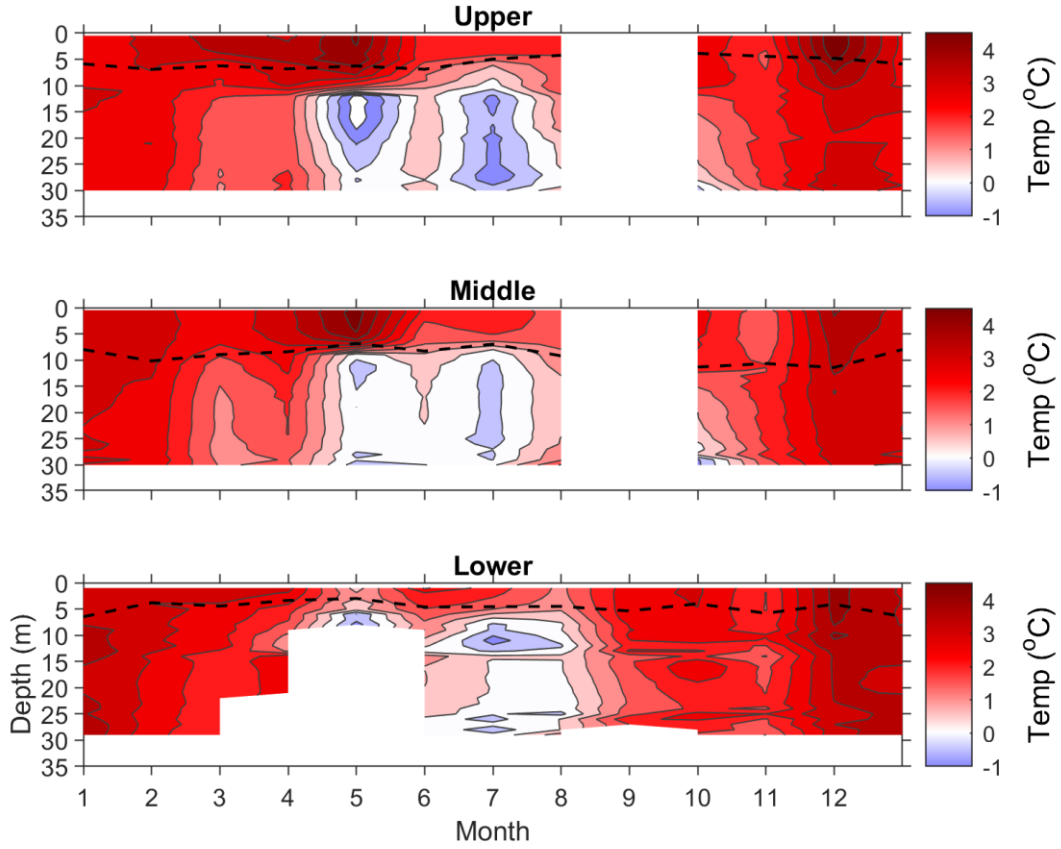
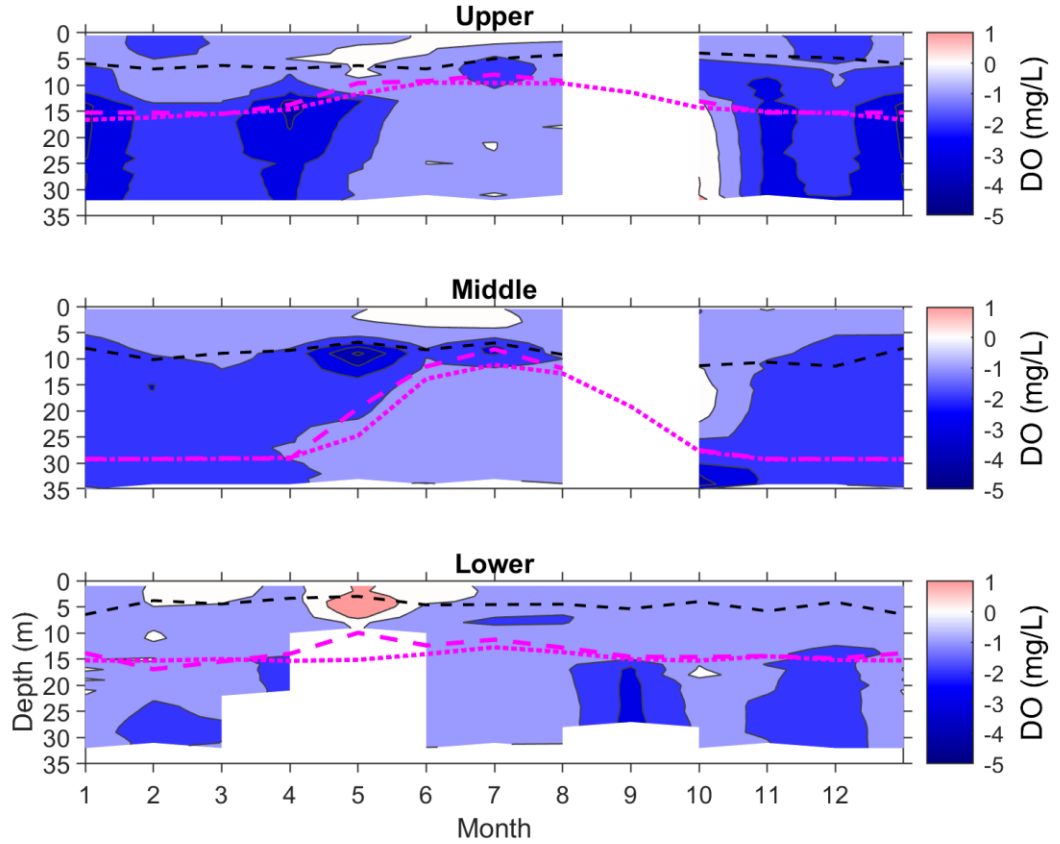


Summary:
Temperature and DO Anomalies





Contact:
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Conclusions

For Temperature & Salinity

- No Discernible Patterns in Salinity Anomalies
- Winter Temperature Anomalies **Larger** and **Penetrate at Depth**
- Summer Temperature Anomalies **Smaller** and **do not Penetrate at Depth**

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- Winter Temperature Anomalies Larger and Penetrate at Depth
- Summer Temperature Anomalies Smaller and do not Penetrate at Depth

For Dissolved Oxygen

- Winter DO anomalies are **negative throughout** water column
- Summer DO anomalies are **negative in the middle of** the water column **Capped by Surface Mixed Layer**

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Conclusions

For Temperature & Salinity

- No Discernible Patterns in Salinity Anomalies
- Winter Temperature Anomalies Larger and Penetrate at Depth
- Summer Temperature Anomalies Smaller and do not Penetrate at Depth

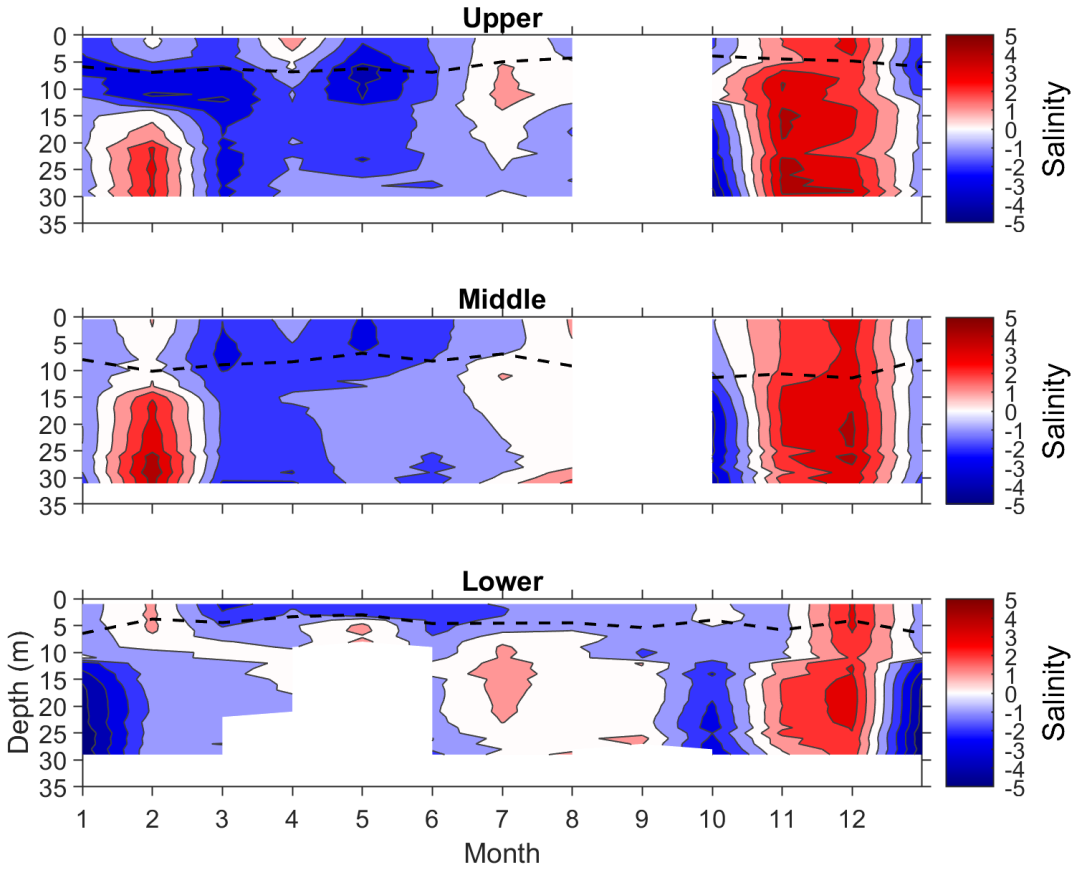
For Dissolved Oxygen

- Winter DO anomalies are negative throughout water column
- Summer DO anomalies are negative in the middle of the water column Capped by Surface Mixed Layer

Future Work

- Examine Chlorophyll Anomalies
- Investigate MLD Definition and Temperature Anomaly Discrepancies

Appendix: Salinity



Appendix: MHW Events