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Supporting Information for

Subsurface evolution and persistence of marine heatwaves in the Northeast Pacific

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Additional Supporting Information (Files uploaded separately)

Introduction

Additional figures and animations are provided to support the primary findings of the analysis and further visualize the spatiotemporal evolution of subsurface marine heatwave anomalies. We also include the availability of Argo mixed layer depths over time in the Northeast Pacific study domain.

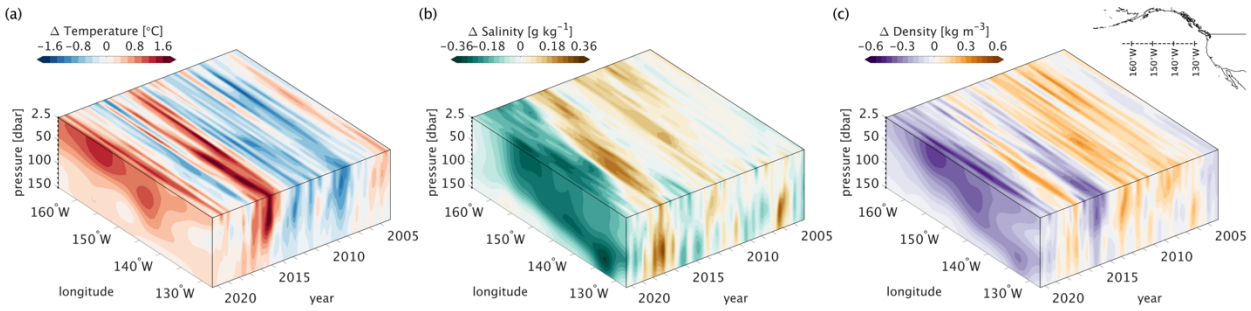

Figure S1. Subsurface evolution and vertical structure of (a) conservative temperature, (b) absolute salinity, and (c) potential density anomalies in the Northeast Pacific vs time (January 2004 through June 2020), pressure (2.5 to 150 dbar) and longitude (164.5–127.5 ºW) at 44.5 °N; see map inset. The objectively mapped Roemmich-Gilson Argo Climatology is used (Roemmich and Gilson, 2009). Anomalies are computed with respect to the January 2004 through June 2020 monthly means.

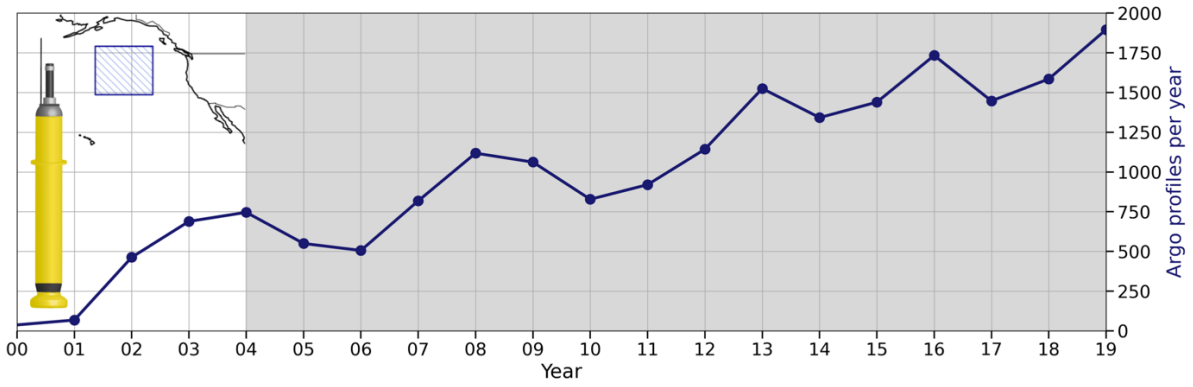

Figure S2. Number of Argo float profiles in the NE Pacific (35.5–51.5ºN, 135.5–154.5ºW; blue boxed region in map inset). Years shaded in gray are used in this analysis and overlap with the Roemmich-Gilson Argo Climatology. We use 19,697 profiles from January 2004 through June 2020. An illustration of a core Argo float is shown measuring 1.3 m in height, 20 cm wide, and approximately 40 kg in weight. These autonomous floats profile the upper 2,000 m on 10-day intervals and measure ambient seawater salinity, temperature, and pressure. The schematic of an Argo float is provided by the Argo Program (https://www.argo.ucsd.edu).

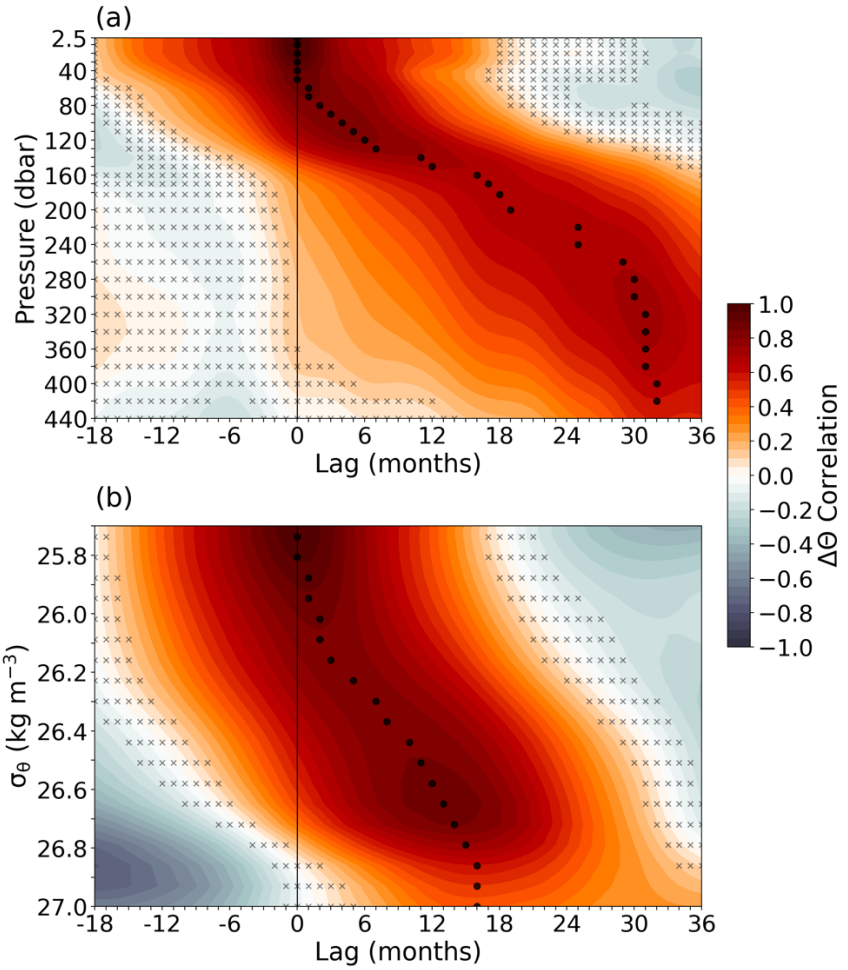

Figure S3. Lagged cross correlation between conservative temperature anomalies at (a) 2.5 dbar and (b) 25.7 kg m^{-3} with subsurface isobars (2.5–440 dbar) and isopycnals (25.7–27.0 kg m^{-3}) respectively. Anomalies are averaged within 35.5–51.5ºN, 135.5–154.5ºW (boxed outline in Figure 1). Cross correlation is computed as the Pearson's r-value ranging from -1.0 to +1.0, with larger absolute values indicating higher correlation. Cross hatching indicates insignificant correlations (p-value >= 0.05) and black circles indicate the highest positive correlation for each isobar (a) and isopycnal (b).

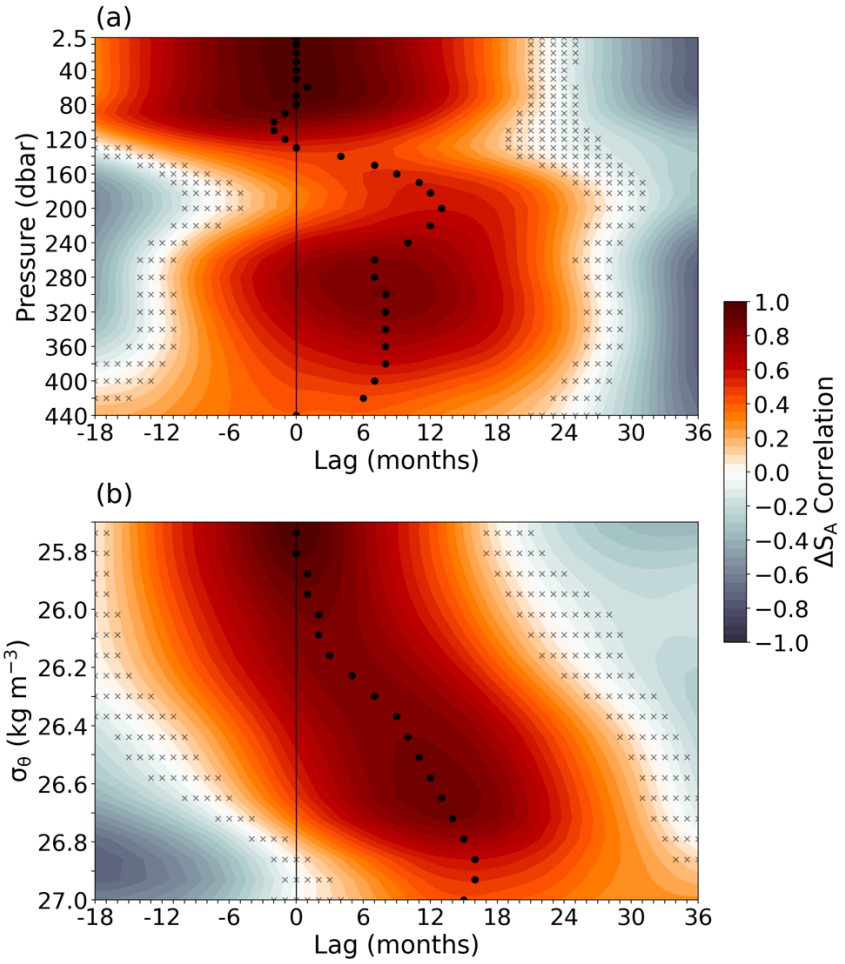

Figure S4. Lagged cross correlation between absolute salinity anomalies at (a) 2.5 dbar and (b) 25.7 kg m^{-3} with subsurface isobars (2.5–440 dbar) and isopycnal (25.7–27.0 kg m^{-3}) respectively. Anomalies are averaged within 35.5–51.5ºN, 135.5–154.5ºW (boxed outline in Figure 1). Cross correlation is computed as the Pearson's r-value ranging from -1.0 to +1.0, with larger absolute values indicating higher correlation. Cross hatching indicates insignificant correlations (p-value >= 0.05) and black circles indicate the highest positive correlation for each isobar (a) and isopycnal (b).

Movie S1. Evolution of monthly (a) sea surface temperature anomalies, (b) absolute salinity on the 25.4 kg m^{-3} isopycnal, and (c) stratification anomaly between 2.5 and 200 dbars in the Northeast Pacific marine heatwave. Contours in (c) show the pressure of the 25.4 kg m^{-3} isopycnal. Sea surface temperature anomalies are from the OISSTv2 where diagonal hatching indicates the locations experiencing a marine heatwave defined when the sea surface temperature exceeds the local monthly 90^{th} percentile averaged. Hatching over absolute salinity is consistent with (a) showing the presence of marine heatwaves in sea surface temperature. All anomalies are referenced to the January 2004 through June 2020 monthly climatology.

Movie S2. Same as in Movie S1 except on the 25.7 kg m^{-3} isopycnal.