

Limnology and Oceanography
Shifting Phenology as a Key Driver of Shelf Zooplankton Population
Variability

SUPPORTING INFORMATION

Authors:

Isabel A. Honda^{1,2*}, Rubao Ji¹, Gregory L. Britten^{1,3}, Cameron Thompson⁴,
Andrew R. Solow¹, Zhengchen Zang^{1,5,6,7}, Jeffrey A. Runge⁸

Affiliations:

¹Biology Department, Woods Hole Oceanographic Institution, Woods Hole, MA

²Department of Civil and Environmental Engineering, Massachusetts Institute of
Technology, Cambridge, MA

³Department of Earth, Atmospheric, and Planetary Sciences, Massachusetts Institute of
Technology, Cambridge, MA

⁴Northeastern Regional Association of Coastal Ocean Observing Systems, Portsmouth,
NH

⁵Department of Oceanography and Coastal Sciences, Louisiana State University, Baton
Rouge, LA

⁶Center for Computation and Technology, Louisiana State University, Baton Rouge, LA

⁷Coastal Studies Institute, Louisiana State University, Baton Rouge, LA

⁸Darling Marine Center School of Marine Sciences, University of Maine, Walpole, ME

*Corresponding author: ihonda@mit.edu

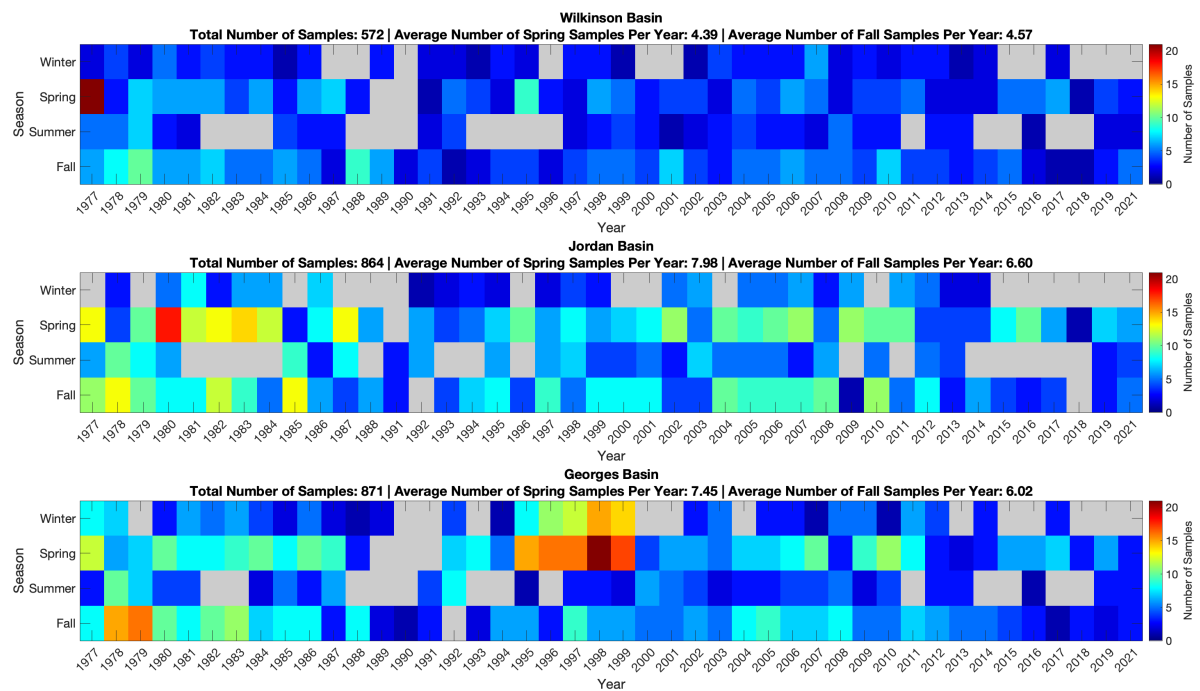


Figure S1: Seasonal distribution of the MARMAP/EcoMon data set for samples collected in Wilkinson Basin, Jordan Basin, and Georges Basin of the Gulf of Maine. Grey shaded boxes indicate that no data were for that season and year.

Basin	Response Variable	n	s(DoY) EDF	p value	s(Year) EDF	p value	ti(DoY, Year) EDF	p value	Adj. R ²	Deviance Explained (%)
Wilkinson Basin	Calfin	562	7.6882	< 2e-16	0.9121	0.06	27.8897	< 2e-16	0.418	45.6
	CSI	565	8.927	< 2e-16	7.059	< 2e-16	26.645	< 2e-16	0.53	56.5
Jordan Basin	Calfin	827	4.7589	< 2e-16	0.8098	0.072	44.5041	< 2e-16	0.404	44
	CSI	800	7.581	< 2e-16	3.797e-04	0.829	52.31	< 2e-16	0.571	60.3
Georges Basin	Calfin	925	5.85	< 2e-16	5.249	< 2e-16	16.967	1.23e-06	0.308	32.9
	CSI	908	8.359	< 2e-16	6.491	< 2e-16	20.803	< 2e-16	0.397	42

Table S1: Summary of Generalized Additive Model (GAM) fits and validation metrics for Wilkinson, Jordan, and Georges Basin.

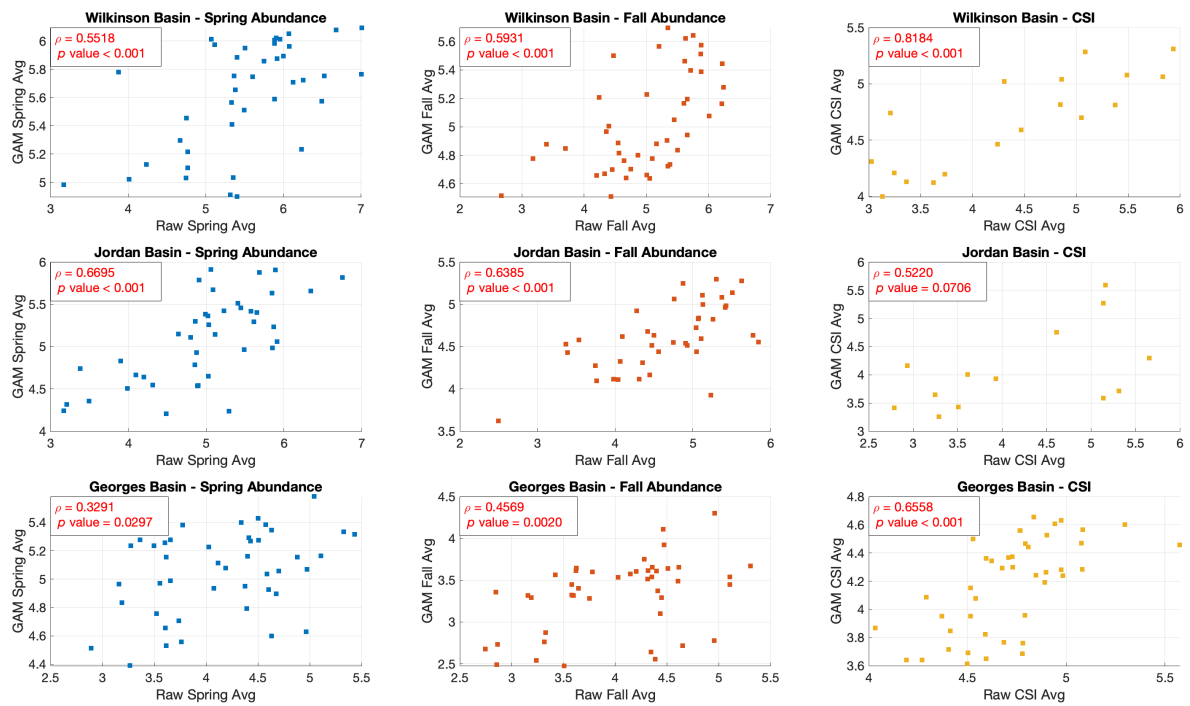


Figure S2: Correlations of the spring, fall, and 75-105 DoY Copepodite Stage Index (CSI) GAM averages with the associated seasonal MARMAP/EcoMon data averages. Average abundances (first two columns) are in units of $\ln(\text{abundance m}^{-3} + 1)$.

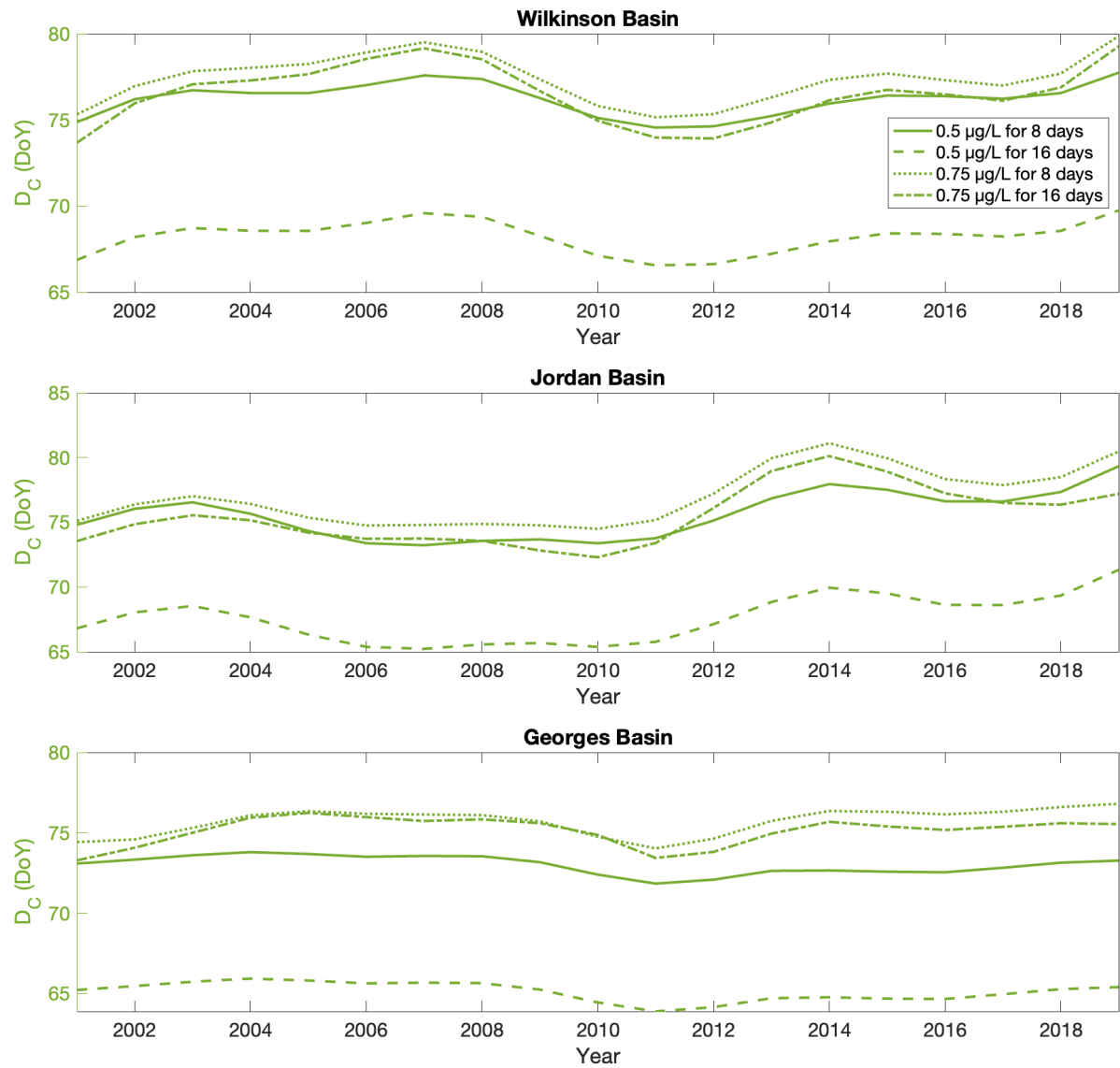
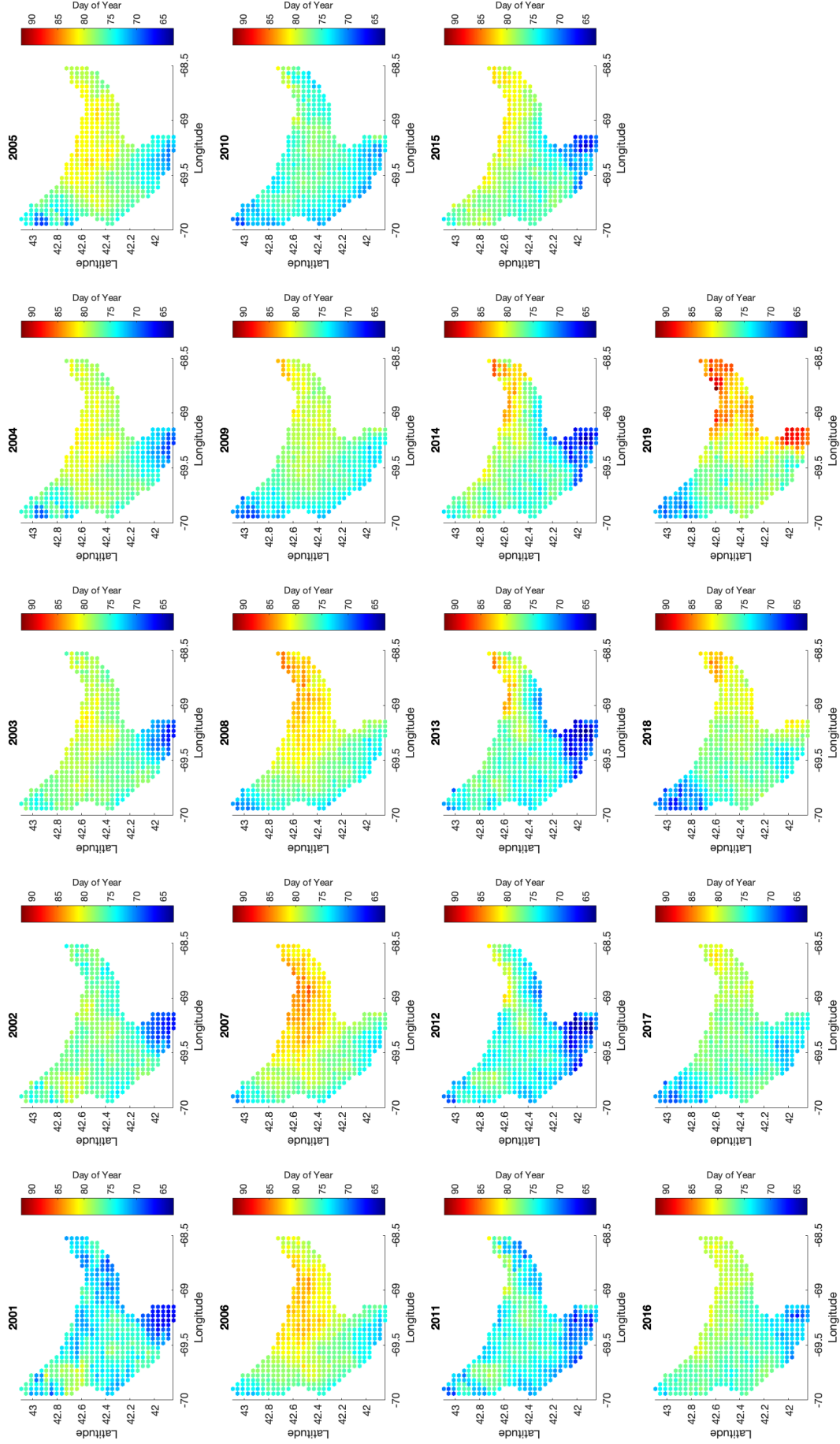
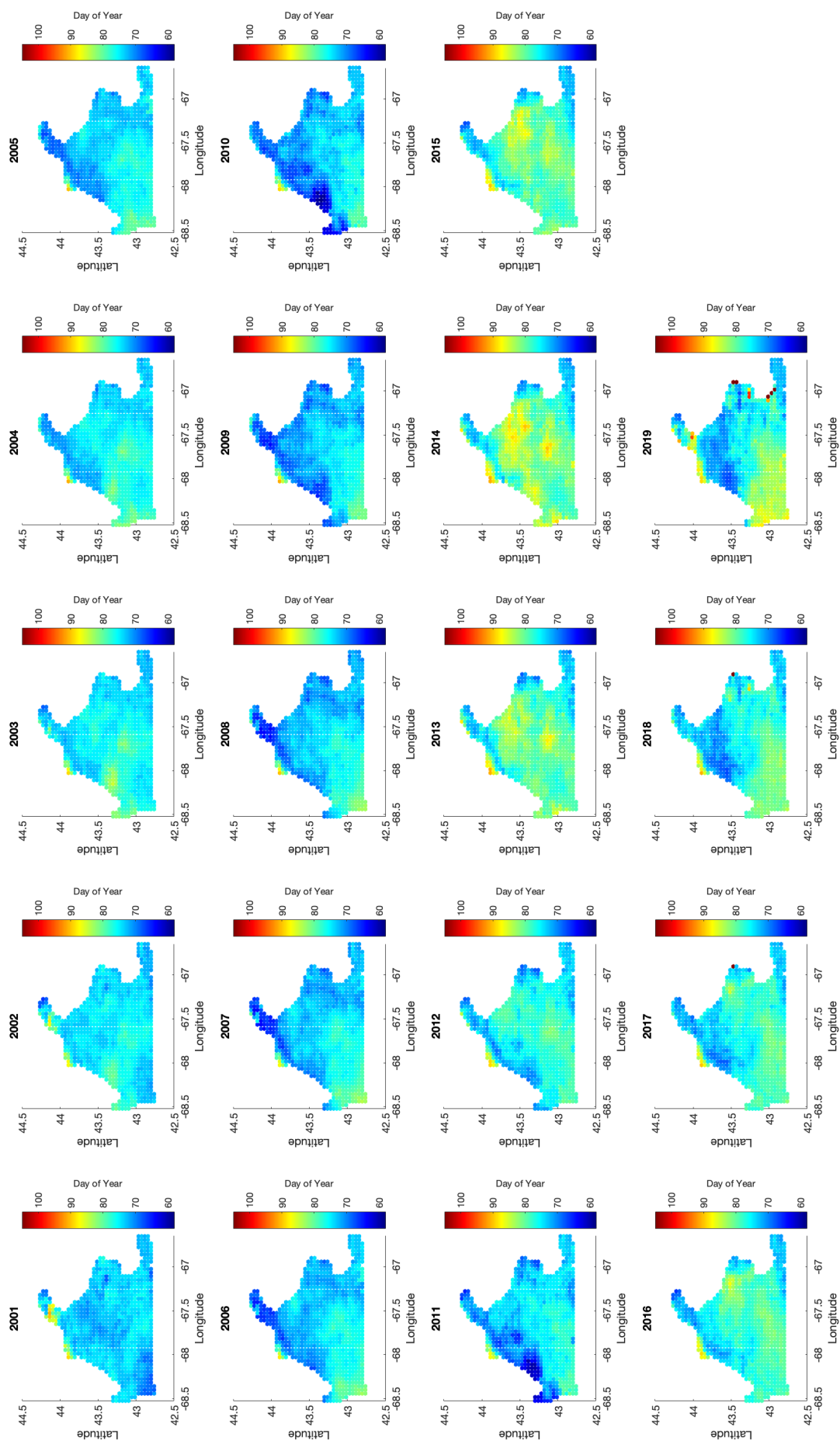
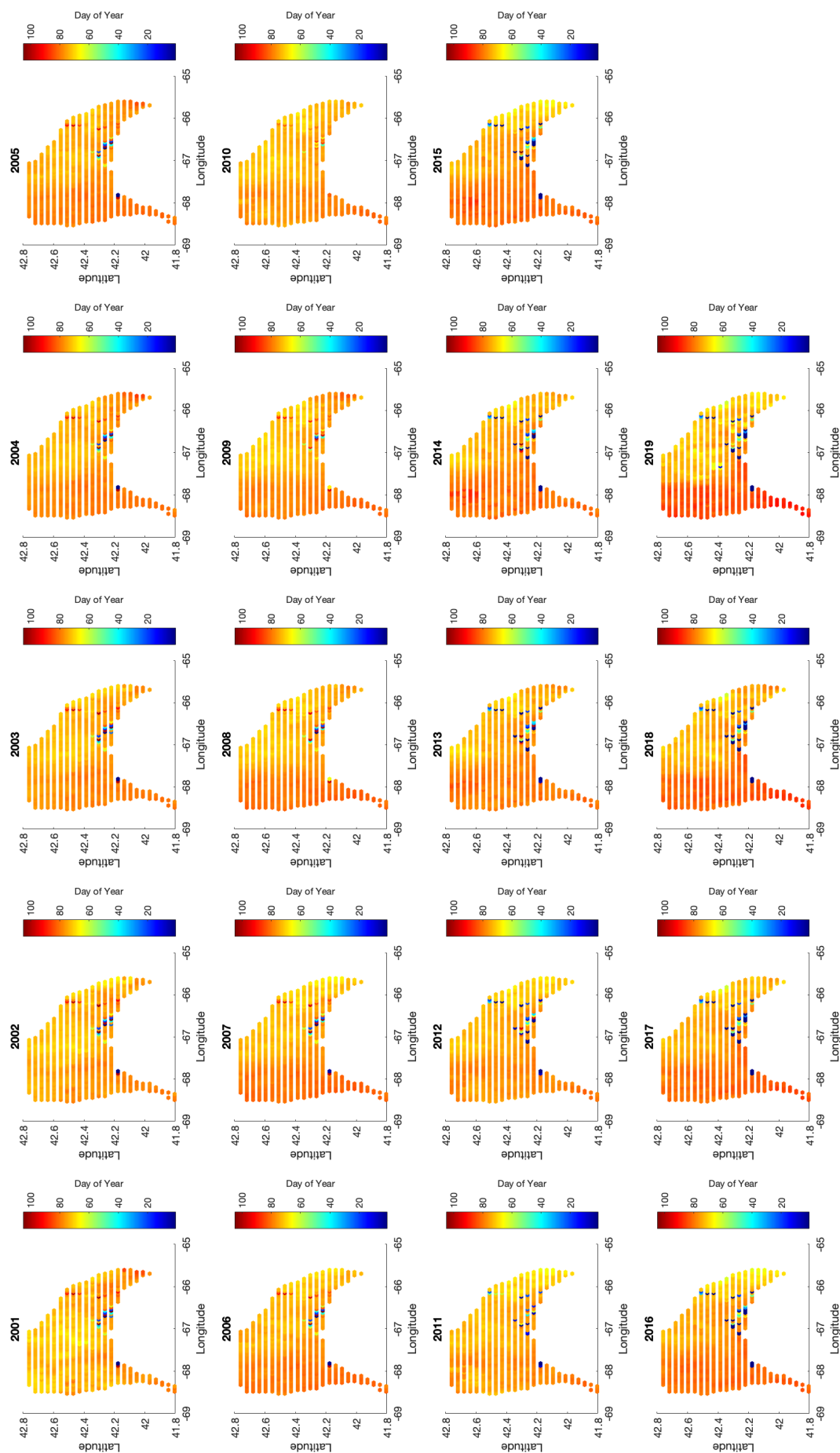


Figure S3: Sensitivity analysis of the magnitude and length of chlorophyll-a concentration threshold for calculating bloom initiation date, or D_C , in units of day-of year (DoY). Across all basins, interannual trends in D_C remain relatively synchronized regardless of the chosen threshold.

Figure S4: Bloom initiation date for each spatial location in Wilkinson Basin across all years of the MODIS-Terra chlorophyll *a* data.

Figure S5: Bloom initiation date for each spatial location in Jordan Basin across all years of the MODIS-Terra chlorophyll *a* data.

Figure S6: Bloom initiation date for each spatial location in Georges Basin across all years of the MODIS-Terra chlorophyll *a* data.

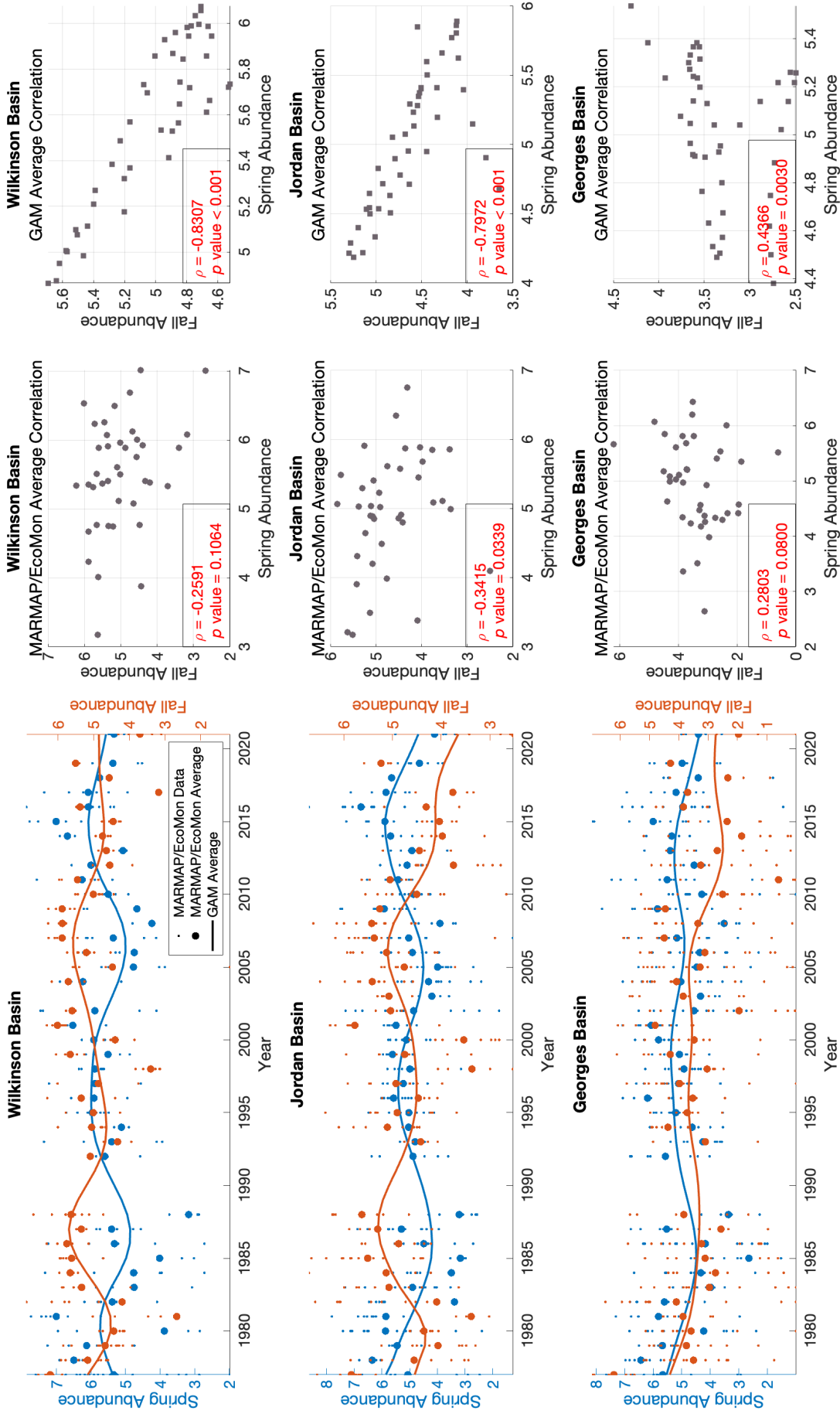


Figure S7: MARMAP/EcoMon Average correlations (seasonal averages of the raw MARMAP/EcoMon data) compared to GAM Average correlations. Due to a lack of data, the MARMAP/EcoMon average correlations exhibit comparatively reduced ρ in magnitude and significance compared to the GAM average correlations. However, the MARMAP/EcoMon averages exhibit consistent directional trends at least to approximately a 90% significance level.

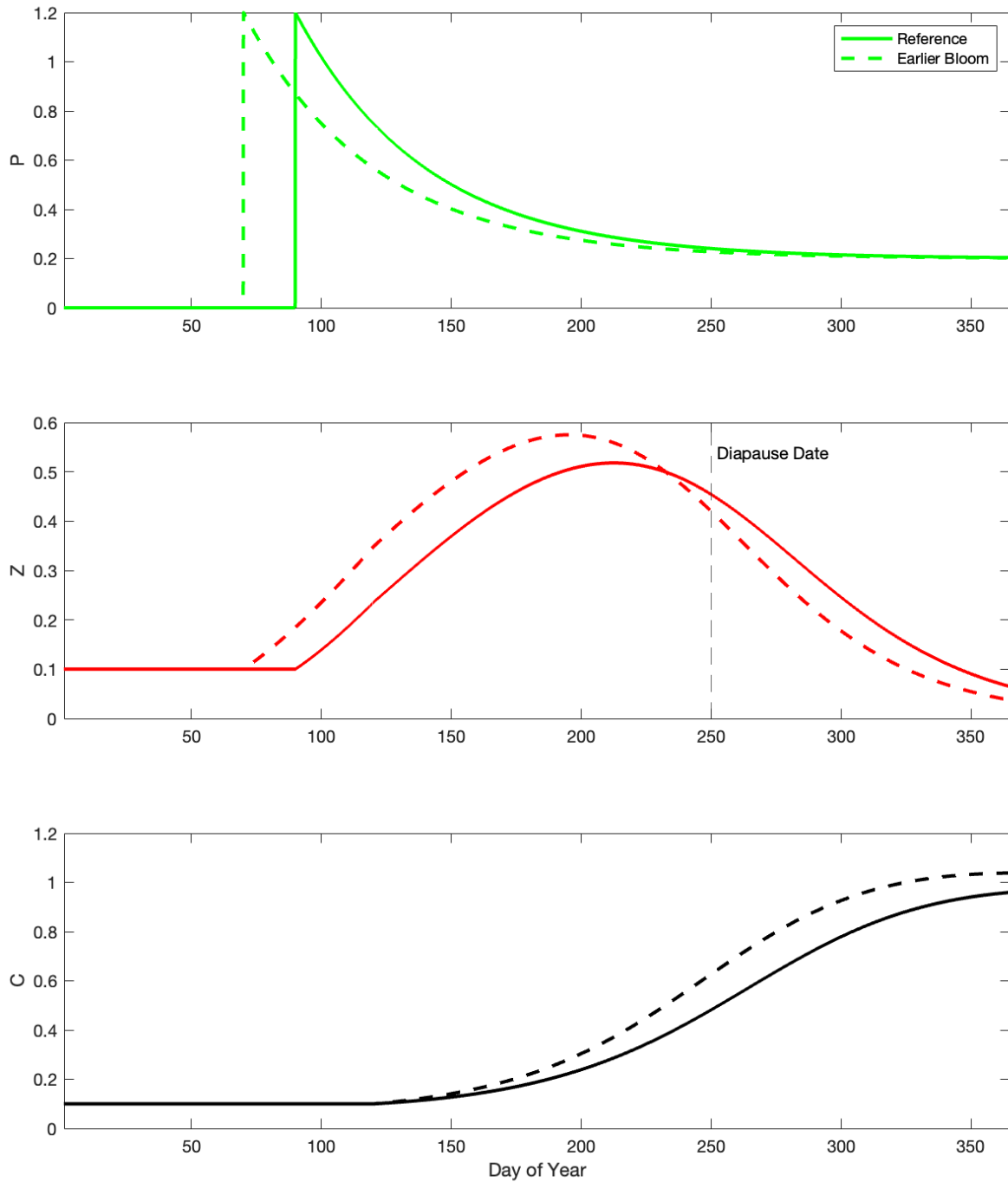


Figure S8: Simple Lotka-Volterra model results demonstrating hypothesized density-dependent predator-prey interactions driving *Calanus finmarchicus* population dynamics in Wilkinson and Jordan Basins. P represents the annual phytoplankton bloom, Z represents *C. finmarchicus* abundance, and C represents potential predators. Refer to <https://github.com/iahonda/Shifting-Phenology.git> for the full model and initial conditions.

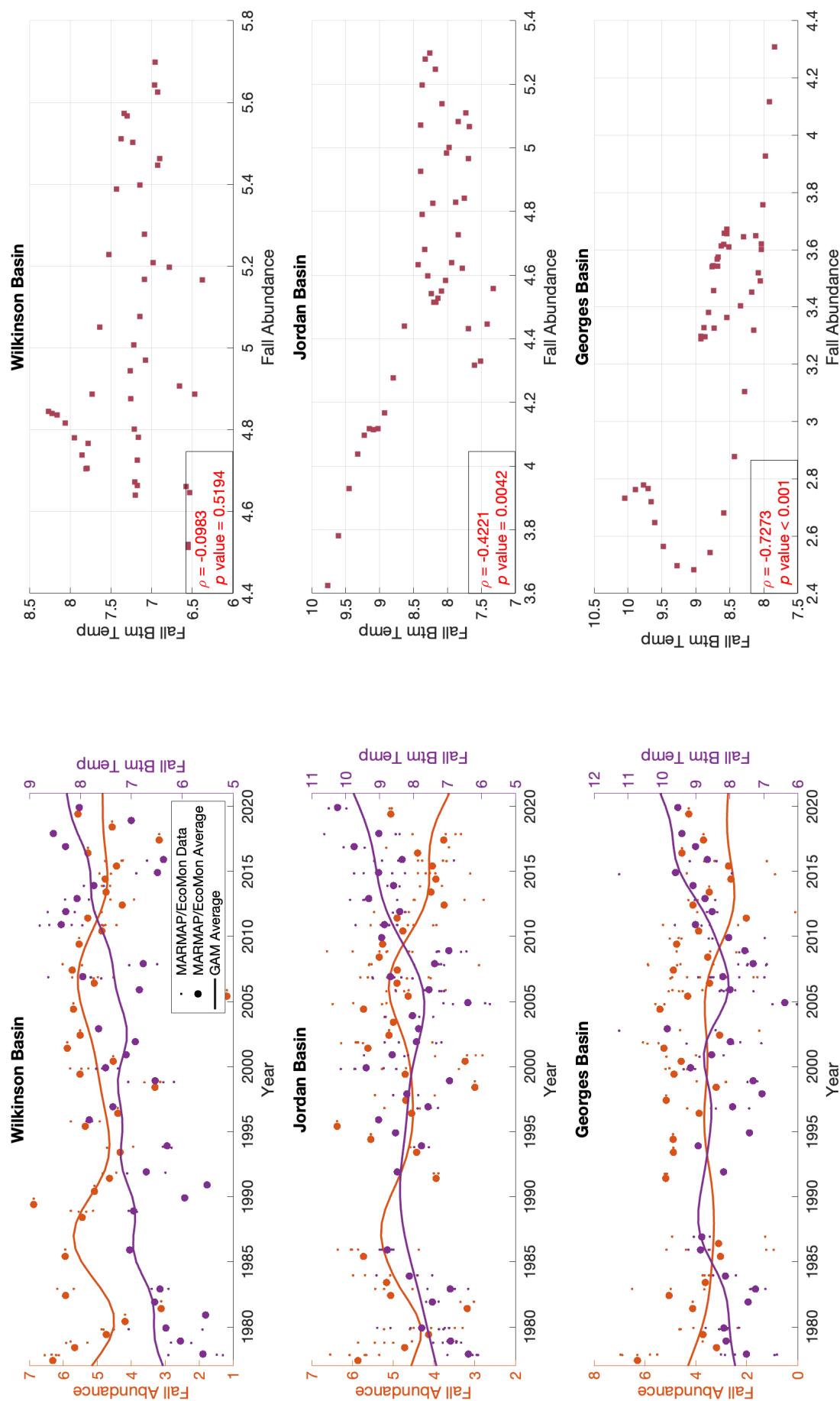


Figure S9: Annual fall abundance and bottom temperature (Btm Temp) data, averages, and trends within the basins of the Gulf of Maine. Left-hand panels show MARMAP/EcoMon samples collected within each basin (small circles) and MARMAP/EcoMon data seasonal averages (large circles), as well as GAM-derived seasonal averages (lines). Right-hand panels display scatter plots with Spearman's rank correlation ρ values and associated p values for each basin. Abundances are in units of $\ln(\text{abundance m}^{-3} + 1)$ and temperature is in units of $^{\circ}\text{C}$.