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A numerical model study of the main factors contributing to hypoxia and its interannual and short-term variability in the East China Sea

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Model-data comparisons of temperature and salinity

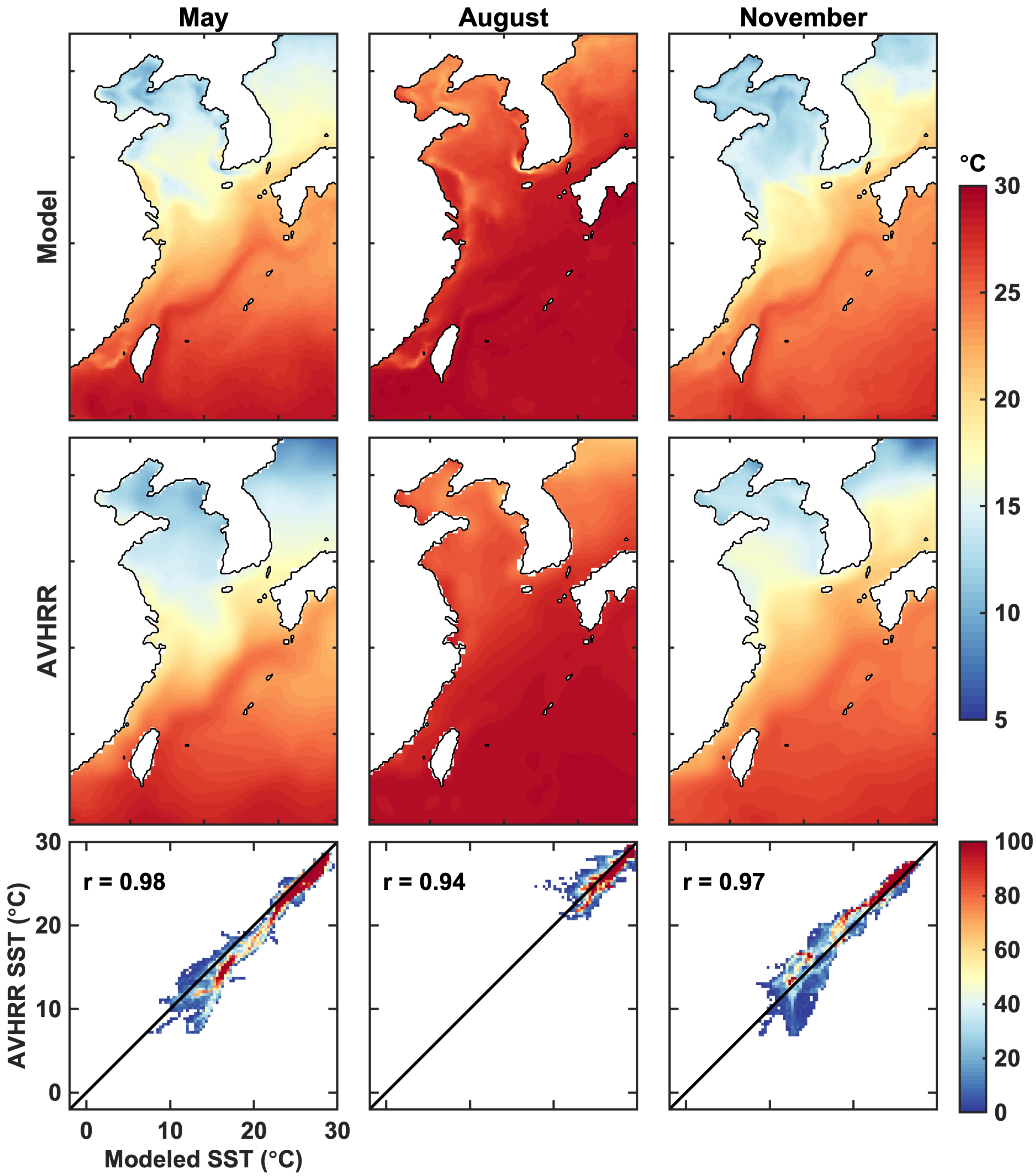

Figure S1. Monthly averaged (2008-2013) SST in the model (top row) and from NOAA AVHRR (row below) in February, May, August and November. 2-dimensional histograms (bottom row) show the corresponding comparisons between model SST and AVHRR SST with correlation reported in each panel. The 1-to-1 line is shown in black. The color scale of the bottom row indicates the number of data pairs in each bin.

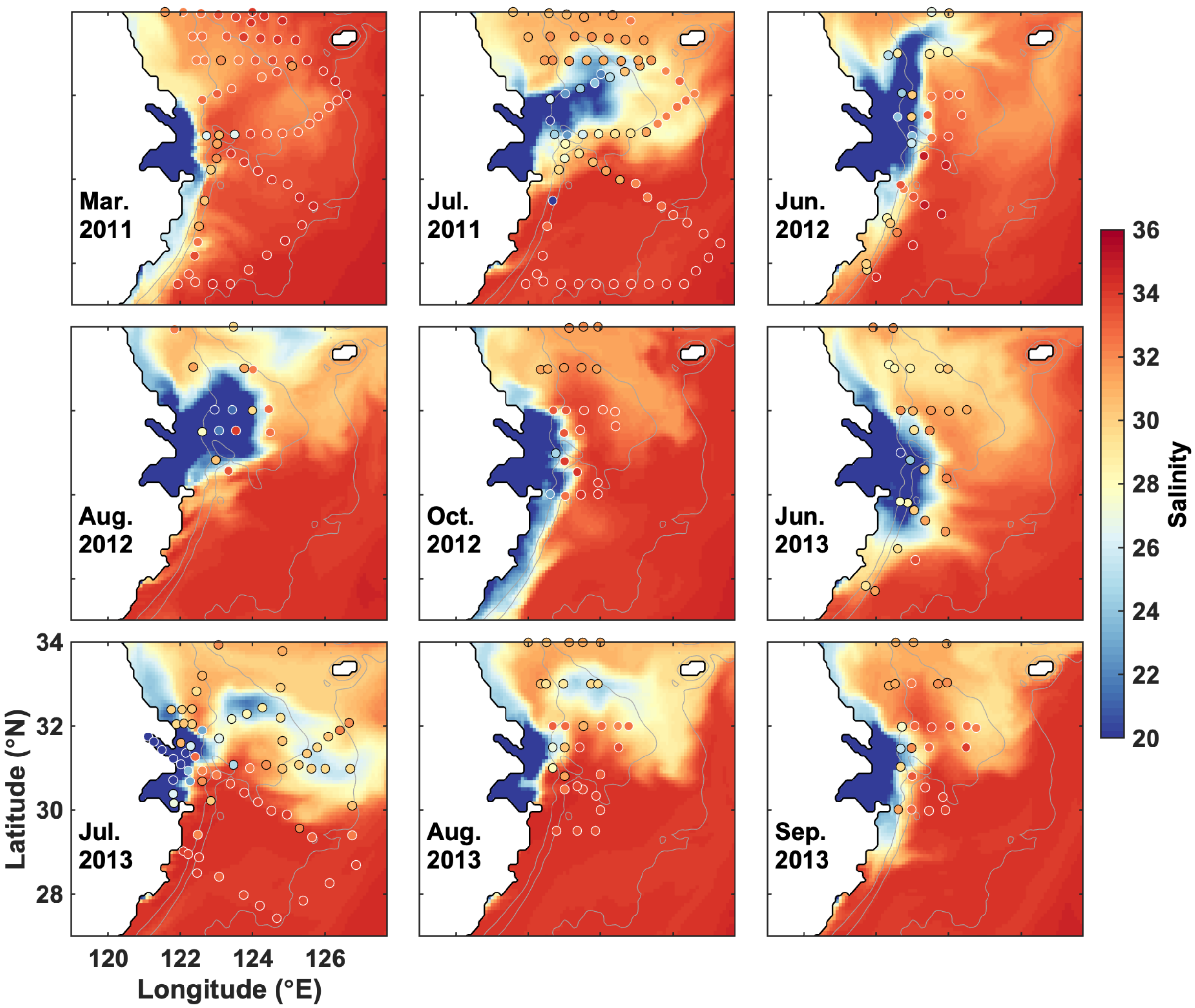

Figure S2. Simulated surface salinity (map) compared with observations (dots) during nine cruises from 2011 to 2013.

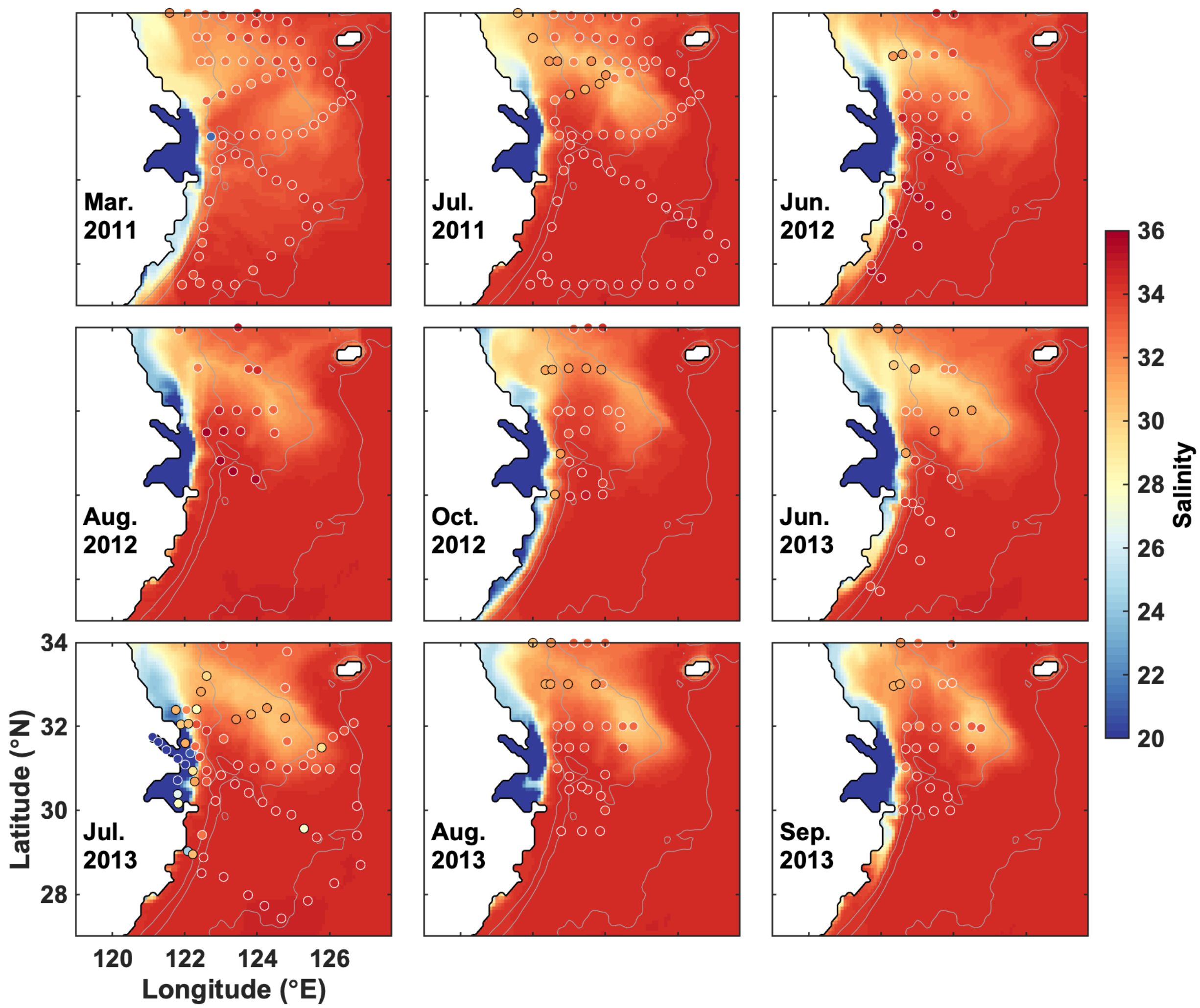

Figure S3. The same as Figure S2 except for bottom salinity.

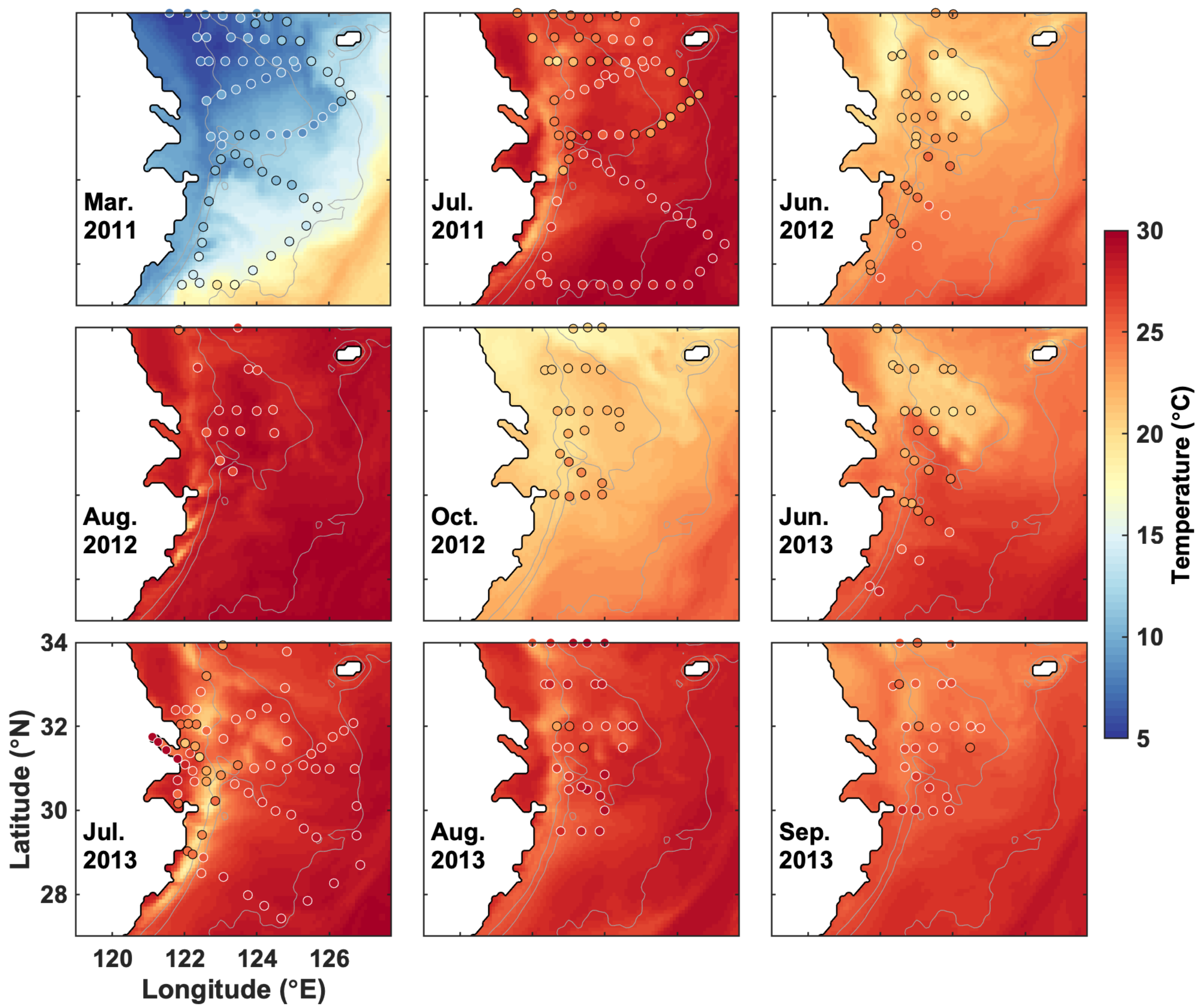

Figure S4. The same as Figure S2 except for surface temperature.

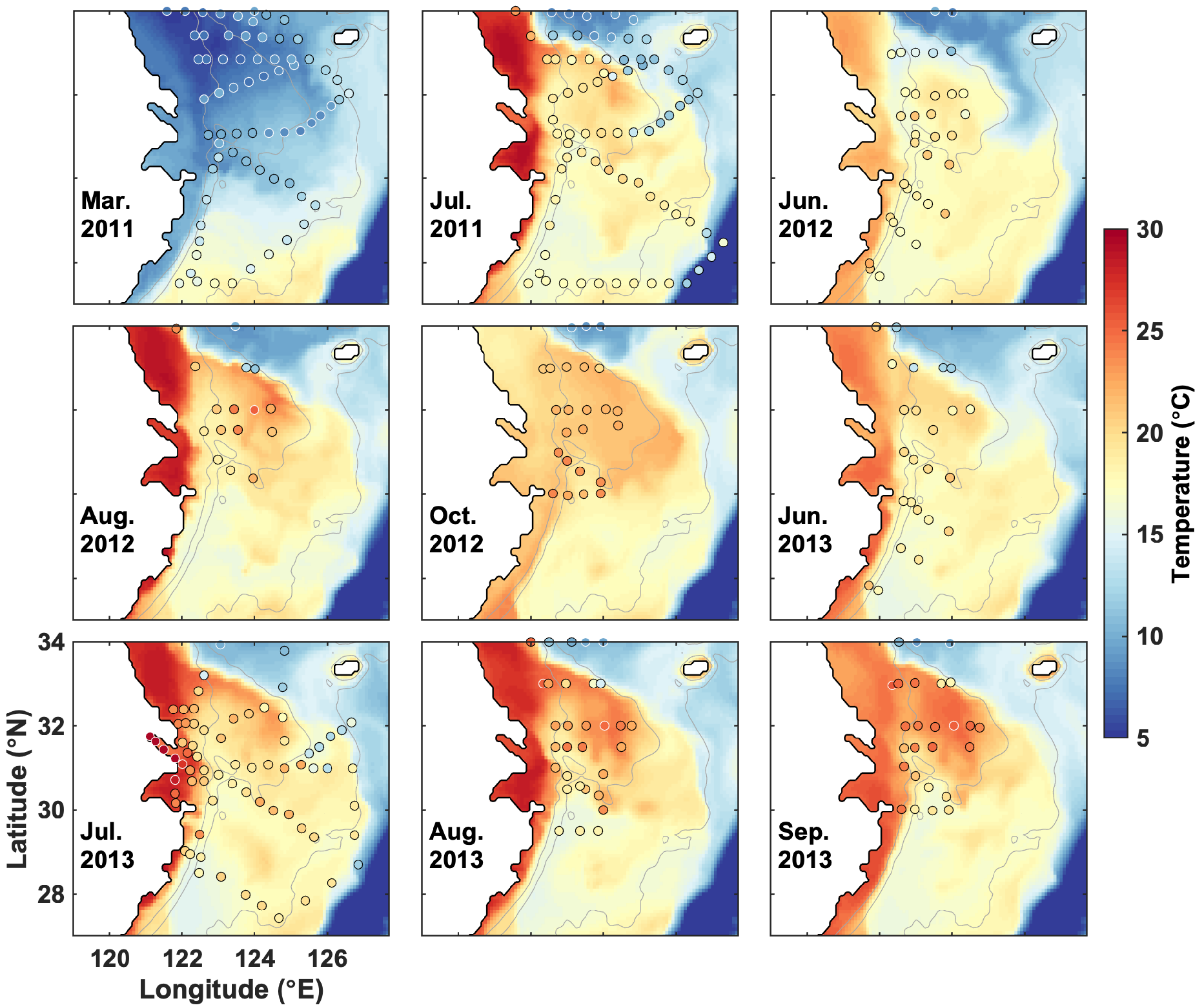

Figure S5. The same as Figure S2 except for bottom temperature.

Assessment of the dominant currents

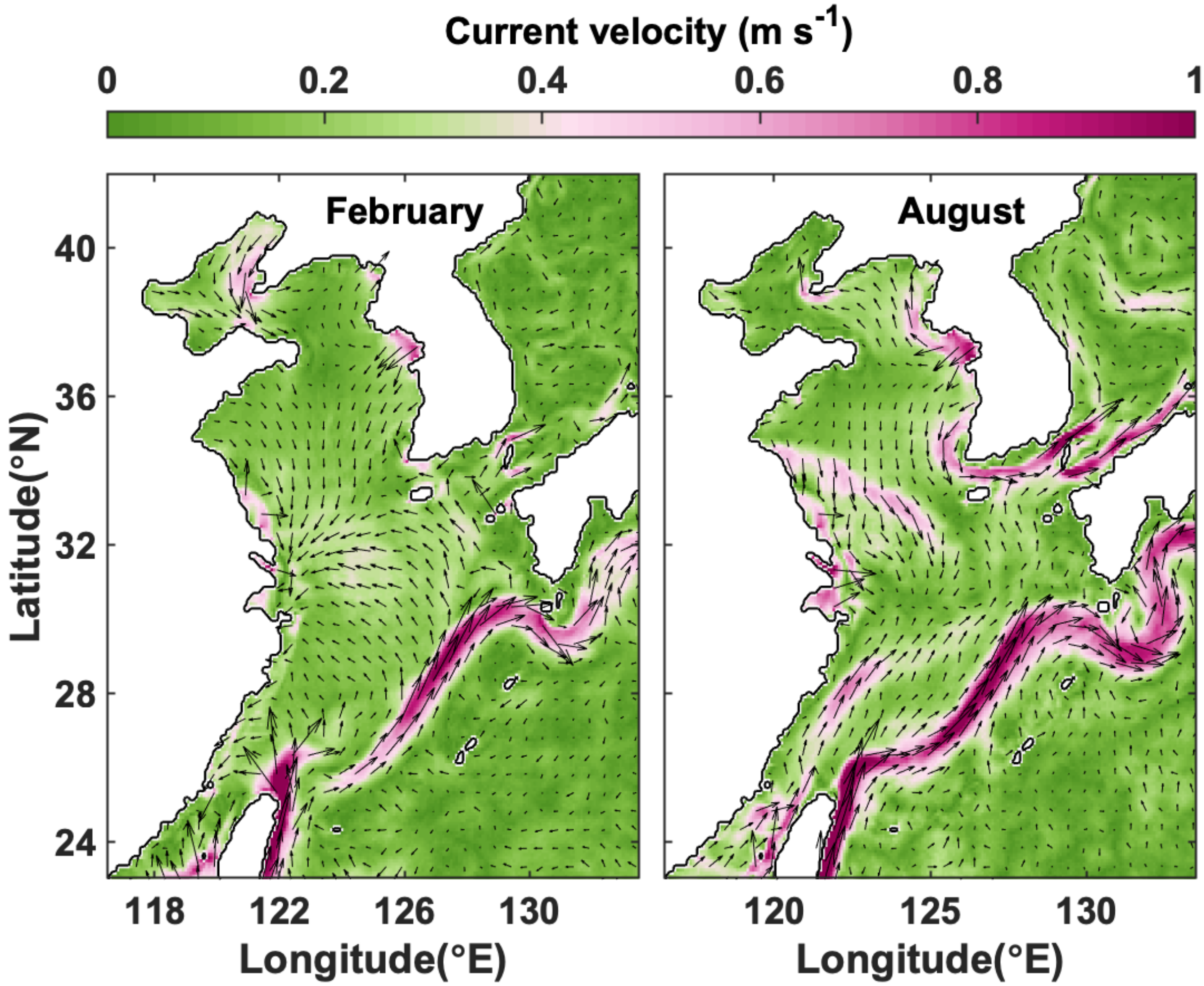

Figure S6. Simulated monthly mean surface currents in February and August. Black arrows represent currents with velocity >= 0.4 m/s, while blue arrows denote velocity <0.4 cm/s.

Model-data comparisons of surface chlorophyll

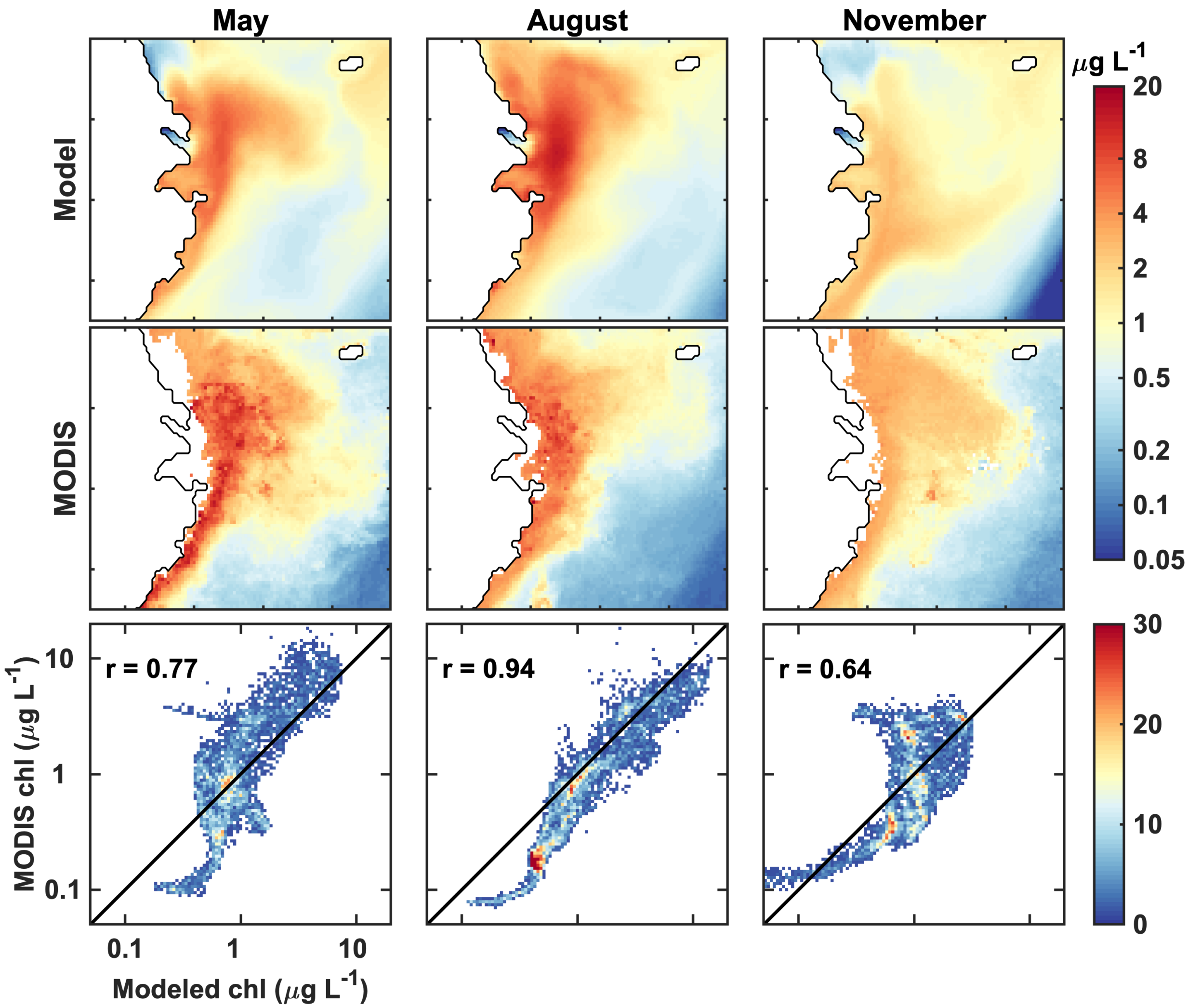

Figure S7. The same as Figure S1 except for surface chlorophyll. Observed surface chlorophyll is from MODIS Terra. No observations are available for the white areas near the coast.

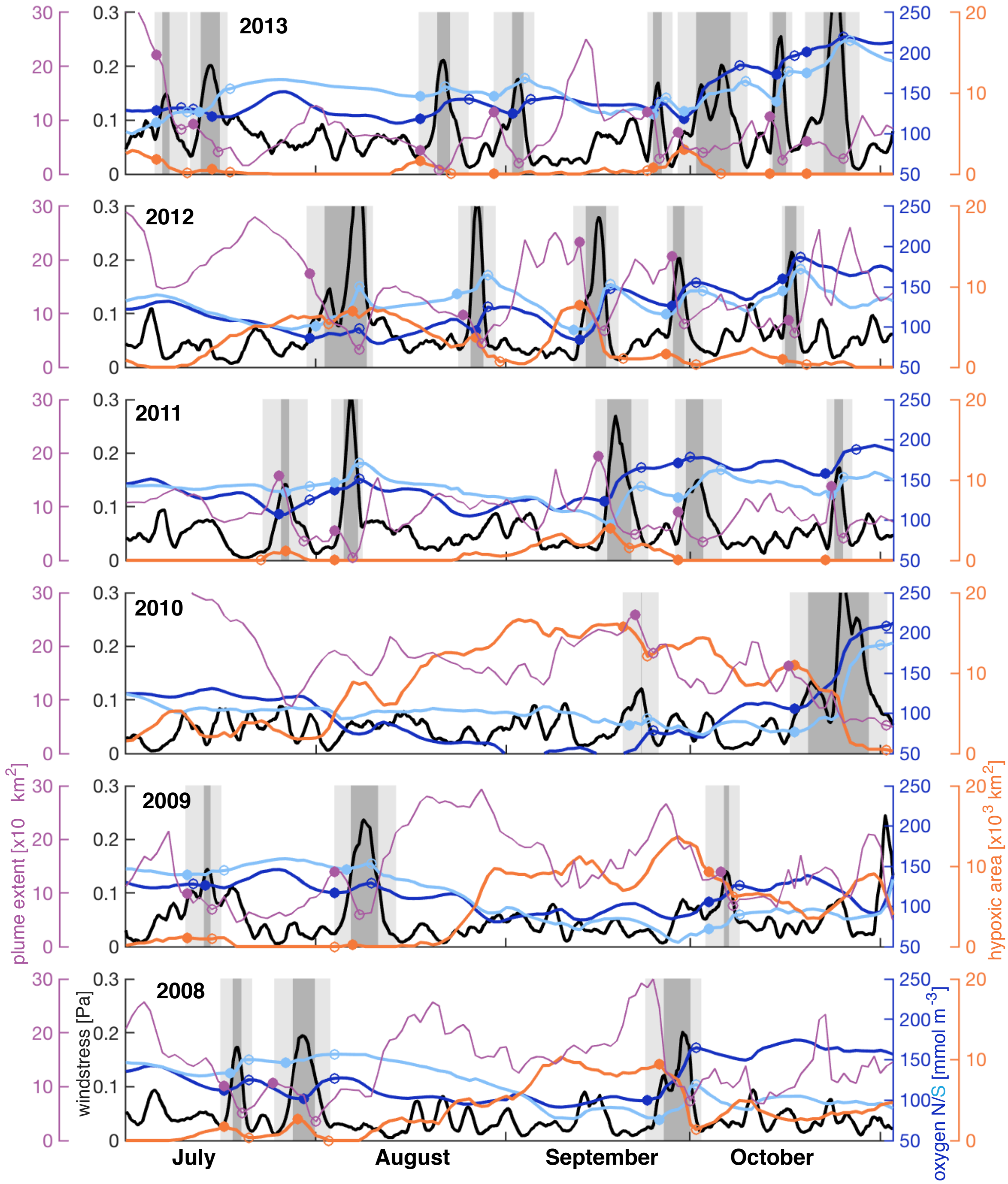

Figure S8. Wind stress (black), mean bottom oxygen in the northern and southern zones (dark and light blue), and total hypoxic extent (orange) and FW plume extent (purple) throughout July to October from 2008 to 2013. The filled and open circles indicate a variables' value at the beginning and after high-wind events. High-wind days/events are indicated by the dark/light gray shading.

Biogeochemical model parameters

Symbol	Parameter	Value	Units
μ_0	phytoplankton growth rate at 0℃	0.59	d^{-1}
k_{NO3}	half-saturation concentration for uptake of NO_3	0.5	mmol N m^{-3}
k_{NH4}	half-saturation concentration for uptake of NH_4	0.5	mmol N m^{-3}
k_{PO4}	half-saturation concentration for uptake of PO4	0.03	mmol P m^{-3}
α	initial slope of the P-I curve	0.025	mgC $mgChl^{-1}$ $(W\ m^{-2})^{-1}$ d^{-1}
k_I	light intensity at which the inhibition of nitrification is half-saturated	0.1	W m^{-2}
I_0	threshold for light-inhibition of nitrification	0.0095	W m^{-2}
m_P	phytoplankton mortality	0.15	d^{-1}
τ	aggregation parameter	0.04	$(mmol\ N\ m^{-3})^{-1}$ d^{-1}
Θ_{max}	maximum chlorophyll to phytoplankton ratio	0.053	mgChl mgC^{-1}
g_{max}	maximum grazing rate	0.6	d^{-1}
k_P	half-saturation concentration of phytoplankton ingestion	2	$(mmol\ N\ m^{-3})^2$
β	assimilation efficiency	0.75	dimensionless
l_{BM}	excretion rate due to basal metabolism	0.1	d^{-1}
l_E	maximum rate of assimilation related excretion	0.1	d^{-1}
m_Z	zooplankton mortality	0.1	$(mmol\ N\ m^{-3})^{-1}$ d^{-1}
r_{SD}	remineralization rate of suspended detritus	0.3	d^{-1}
r_{LD}	remineralization rate of large detritus	0.01	d^{-1}
r_{RD}	remineralization rate of riverine dissolved organic matter	0.03	d^{-1}
n_{max}	maximum nitrification rate	0.2	d^{-1}
w_{Phy}	sinking velocity of phytoplankton	0.1	m d^{-1}
w_{SDet}	sinking velocity of suspended detritus	0.1	m d^{-1}
w_{LDet}	sinking velocity of larger particles	5	m d^{-1}

Table S1 Biological model parameters used in this study.

Oxygen budget

Water column	year	northern hypoxic region						southern hypoxic region					
		air-sea	adv	pp	WR	SOC	sum	air-sea	adv	pp	WR	SOC	sum
Whole column	2008	-3.86	-2.53	11.84	-3.85	-4.45	-2.85	-1.73	-1.40	5.85	-2.54	-2.19	-2.00
	2009	-3.86	-2.04	12.57	-4.25	-4.63	-2.21	-1.56	-1.22	6.13	-2.81	-2.19	-1.65
	2010	-4.36	-1.91	11.84	-3.79	-4.61	-2.84	-2.33	-1.19	6.94	-2.88	-2.67	-2.14
	2011	-3.75	-2.86	11.49	-3.82	-4.04	-2.99	-1.55	-1.60	5.58	-2.52	-2.04	-2.13
	2012	-4.02	-1.93	11.36	-3.39	-4.30	-2.29	-1.52	-1.21	5.85	-2.46	-2.17	-1.51
	2013	-3.60	-1.97	12.45	-3.89	-4.39	-1.40	-1.80	-1.57	6.81	-2.64	-2.29	-1.48
		diff	adv	pp	WR	SOC	sum	diff	adv	pp	WR	SOC	sum
Bottom water	2008	4.17	1.97	0.23	-1.04	-4.45	0.88	1.32	3.39	0.13	-0.56	-2.19	2.09
	2009	4.22	2.91	0.20	-1.10	-4.63	1.60	1.26	2.49	0.12	-0.61	-2.19	1.08
	2010	3.85	1.76	0.17	-1.00	-4.61	0.17	1.17	1.82	0.10	-0.66	-2.67	-0.24
	2011	4.22	1.55	0.25	-1.13	-4.04	0.85	1.31	2.31	0.15	-0.62	-2.04	1.11
	2012	3.58	1.53	0.16	-0.92	-4.30	0.05	1.40	2.52	0.12	-0.59	-2.17	1.28
	2013	4.75	3.25	0.27	-1.12	-4.39	2.76	1.26	4.01	0.14	-0.60	-2.29	2.51

Table S2. Oxygen budget for the period during which oxygen decreases (March to August) in different years for the whole water column and the bottom water respectively (unit: mol O_2 m^{-2}).