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Evolution of biogeochemical properties inside poleward undercurrent eddies in the southeast Pacific Ocean

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Supplementary material

Figures

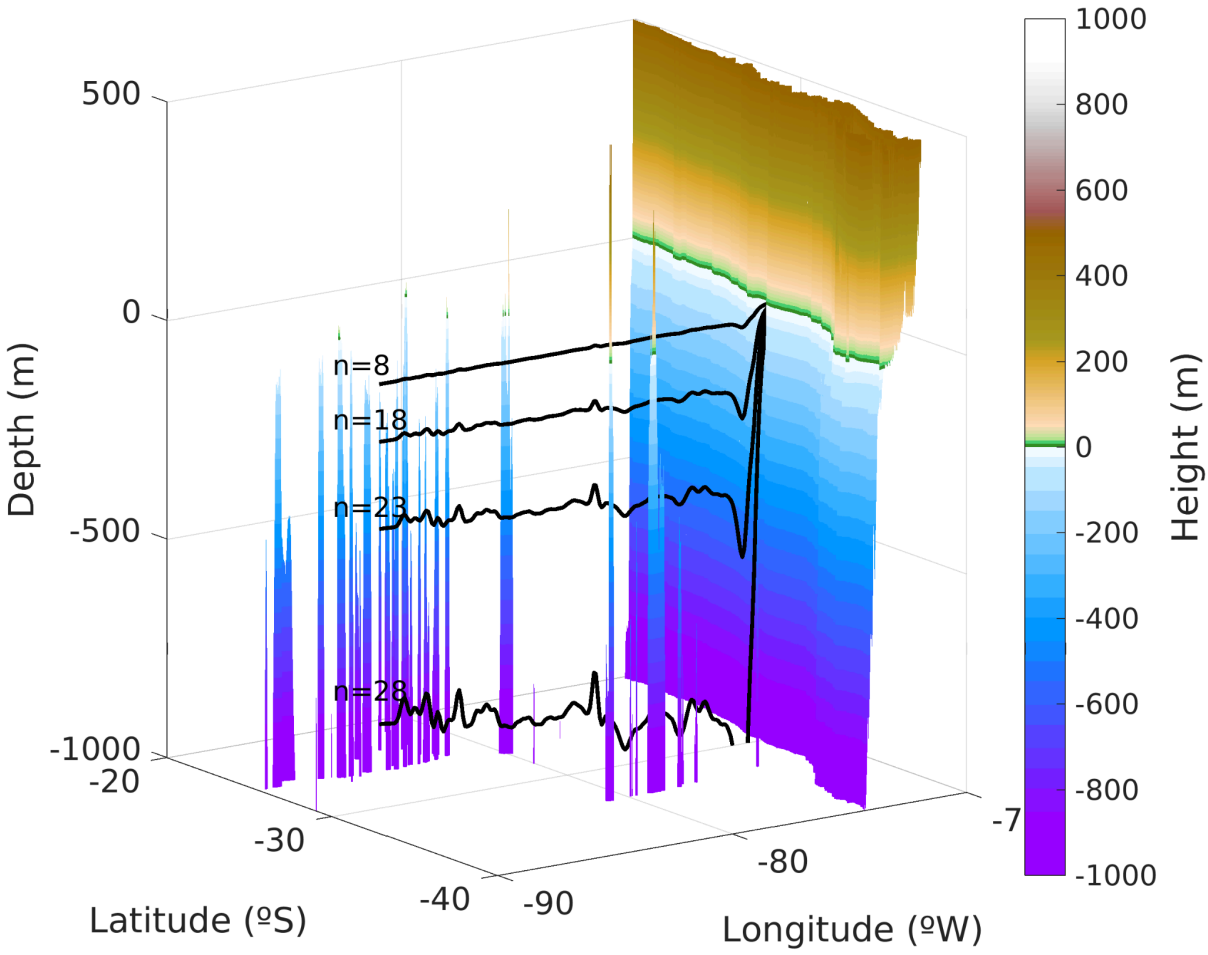

Figure S1. Bathymetry of the study zone. The study area extends between 20 - 40ºS, from the coast to 90ºW and includes the first 1000 m of depth, where eddies have a higher incidence. The color map distinguishes between the marine area (blue and purple colors) and the terrestrial area (brown and green colors). Model configuration includes n=37 sigma levels, with n=28 spanning from the surface to approximately 1000 m depth and 9 additional levels for depths >1000 m. At 30ºS we illustrate some sigma levels (black lines) corresponding to the stratification in January 2002 as an example. The displayed sigma levels are: n=8 (range: -27 to -47 m), 18 (range: -150 to -260 m), 23 (range: -340 to -570 m), and 28 (range: -760 to -1280 m) These depth ranges are independent of the slope area.

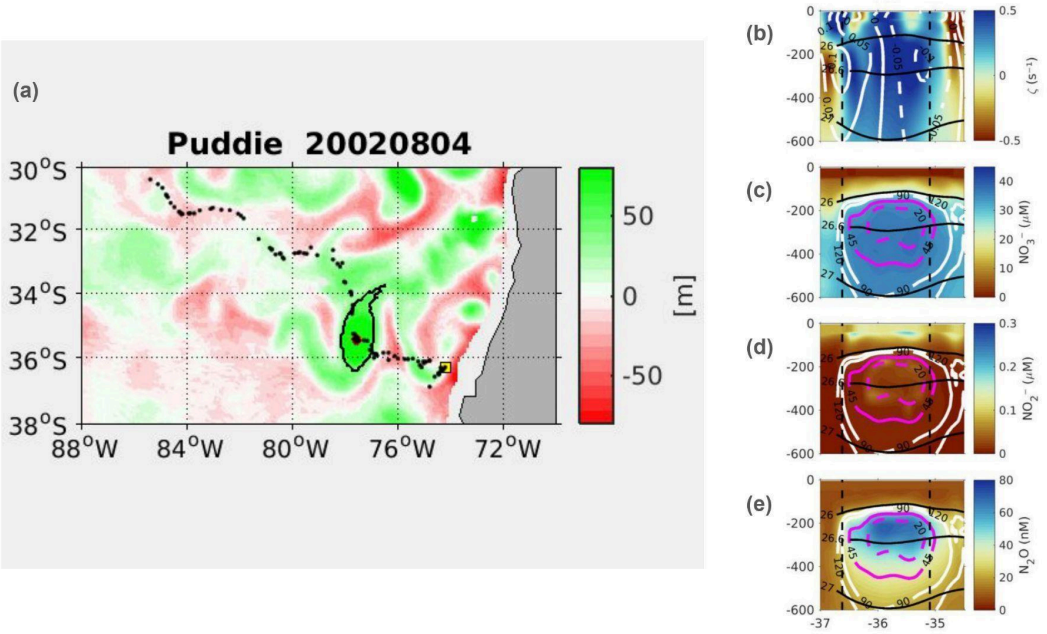

Figure S2. Identification and vertical characterization of a Puddy. It was identified with the Faghmous algorithm where we used the maximum positive anomaly of the layer thickness (δh, colormap) that is bounded by the density surfaces S_{upper} = 26.0 kg m^{-3} and S_{lower} = 26.9 kg m^{-3}, $\delta h > 0$ indicates the anticyclonic polarity, the largest closed contour around the geographical location of δh_{max} is considered as the edge of the eddy (black close contour), as δh_{max} is associated with the center of the eddy (black points; see Section 2.5). Eddy was located at 76.5ºW, 35.8ºS with ~21 weeks of life. (b-e) The vertical structure of Puddy shows the isopycnal layers S_{upper}, S_{core} and S_{lower} (black contours). The edge (black dotted line) with a radius of 73 km. b) Relative vorticity and velocity field, zonal component velocity (white lines) indicates westward flow (dashed line) and eastward flow (solid line). c) NO_3^-, d) NO_2^- and e) N_2O. The core with low oxygen (magenta lines) encloses hypoxia (O_2 < 45 µM, solid line) and suboxia (O_2 < 20 µM, dashed line). White contours enclose oxygen concentrations of 90 and 120 uM.

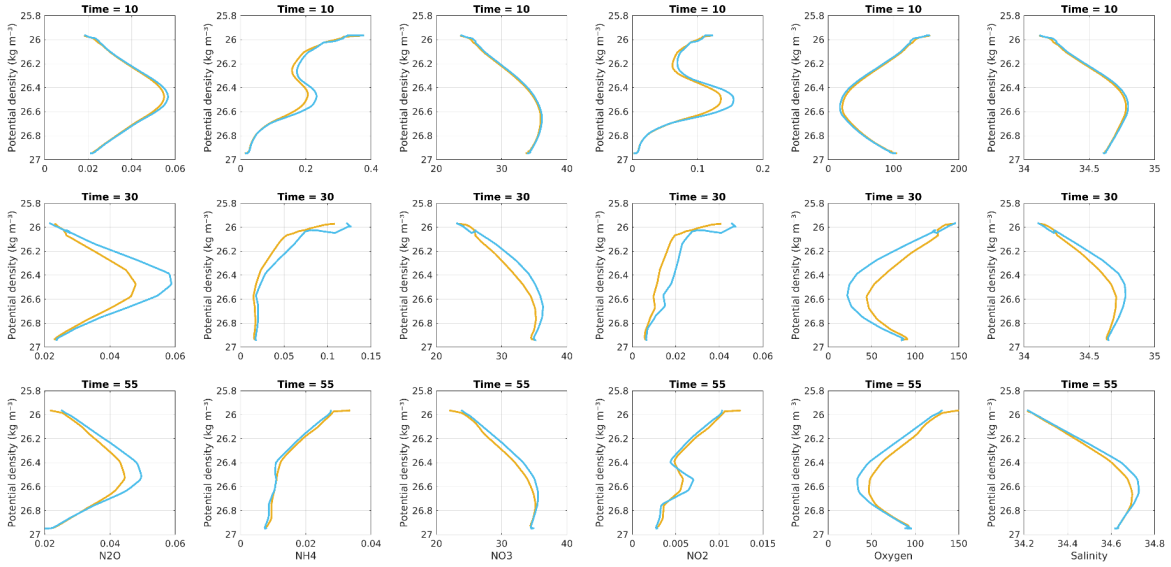

Figure S3. Comparison of the average vertical profile considering an eddy delineated with a circular boundary (orange line) versus an irregular boundary obtained by the Faghmous method (blue line) for each biogeochemical tracer (N_2O, NH_4, NO_3, NO_2, O_2 in µmol) and absolute salinity (in g/kg). The selected times correspond to the early stage (t=10, ~2 months), mid-stage (t=30, ~6 months), and late stage (t=55, ~11.5 months) of the eddy's life cycle. The vertical profile was obtained following the methodology outlined in Section 2.6.2.

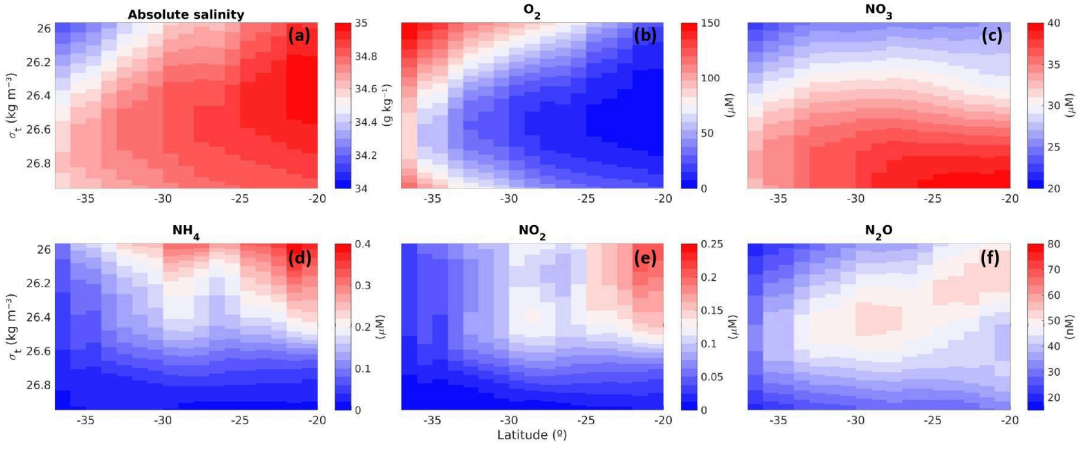

Figure S4. Mean state of different properties at the first ~100 km from the slope where there are higher occurrence Puddies (strip in color red, Figure 1 - right box). The typical characteristics were obtained averaging in areas of 1ºx1º along the coast between the isopycnals layers S_{upper} and S_{lower} by 9 years (See Methods 2.2). (a) absolute salinity, (b) oxygen, (c) nitrous oxide, (d) ammonium, (e) nitrite, (f) nitrate.

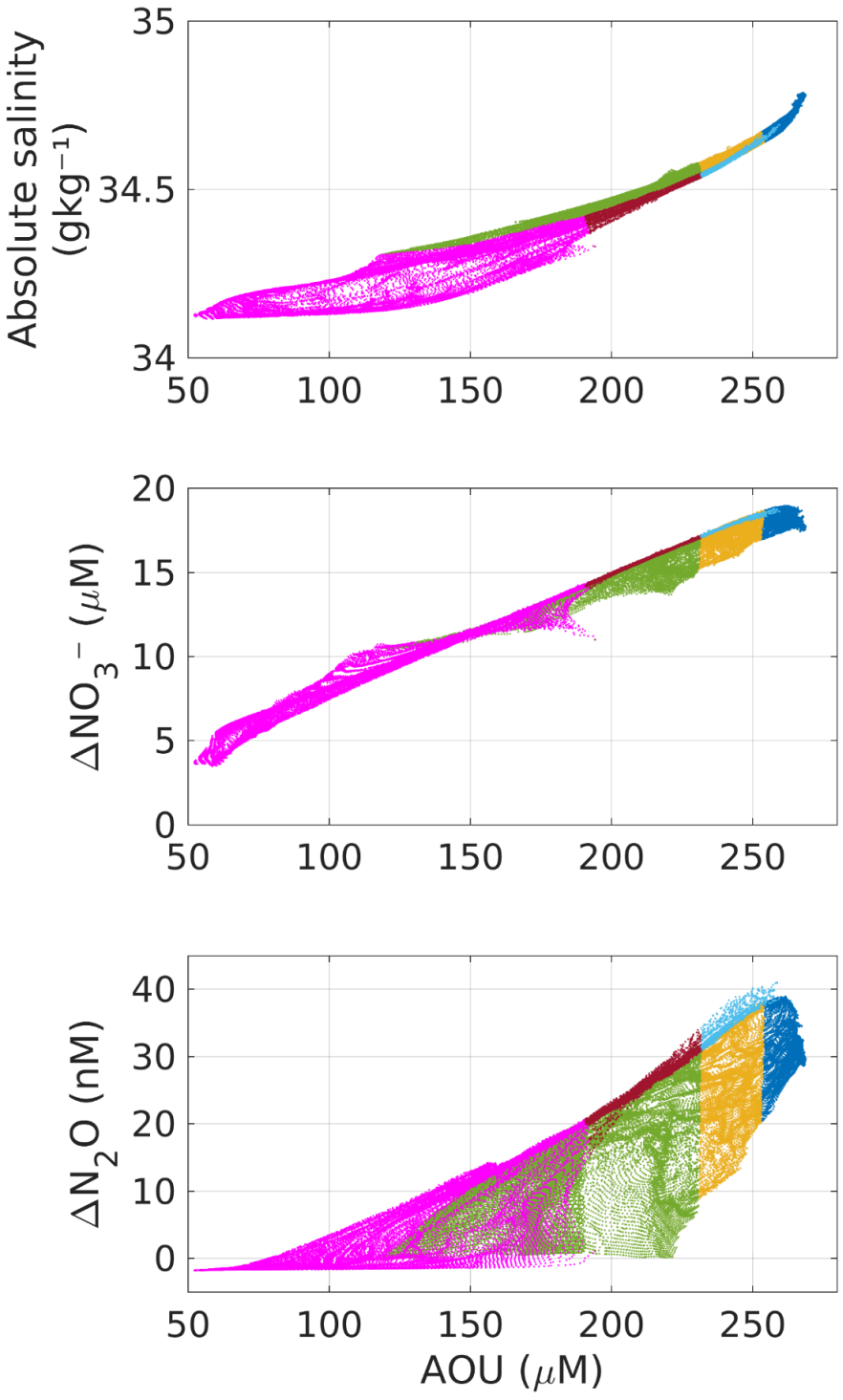

Figure S5. Mean state of biogeochemical characteristics in the S_{core} layer (26.6 kg m^{-3}) in the six subregions. Relations between AOU and (b) absolute salinity, (c) ΔNO_3^-, and (d) ΔN_2O. The subregions are: Northern Coastal Zone (NCZ - dark blue); Northern Transition Zone (NTZ - yellow); Northern Oceanic Zone (NOZ - green); Southern Oceanic Zone (SOZ - magenta); Southern Transition Zone (STZ - brown) and Southern Coastal Zone (SCZ - light blue).

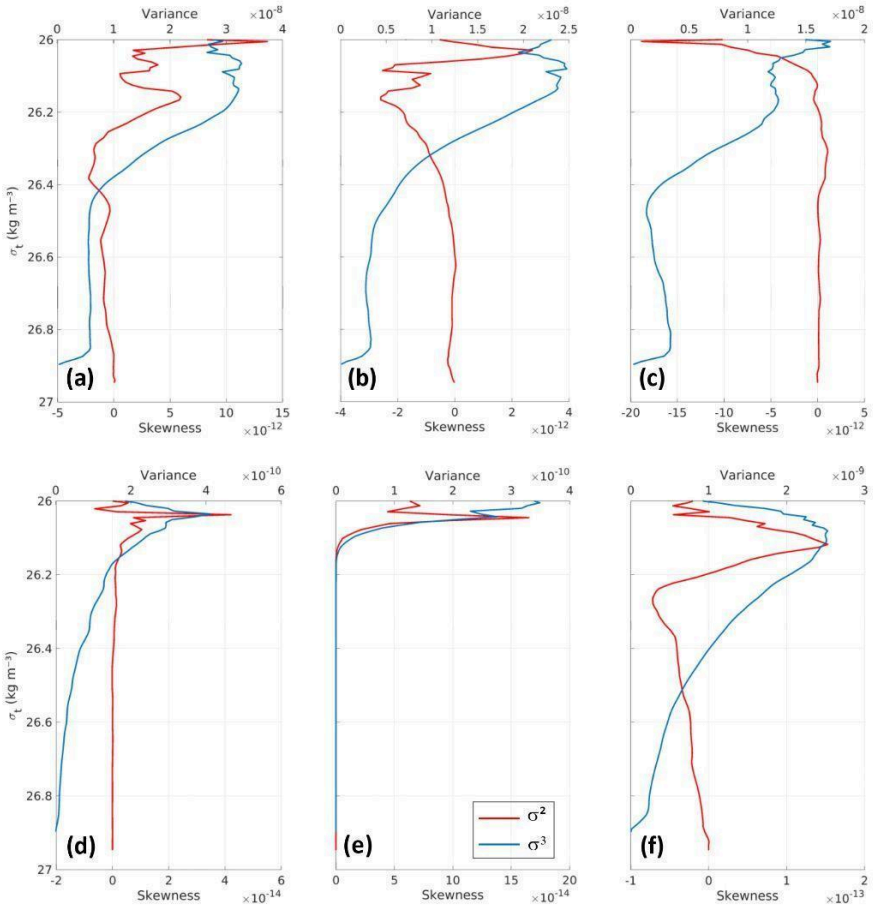

Figure S6. Spatially averaged (red) variance and (blue) skewness of the anomalies of the tendency terms of the oxygen budget for Puddies within the first ~100 km from the slope (strip in green color, Figure 1b). (a) XADV, (b) YADV, (c) VADV, (d) HMIX, (e) VMIX, (f) PHYS (same notation as in Figure 7). The variance and skewness are amongst each profile inside Puddies and the spatial average is then applied.

Tables

Table S1. Average values of AOU (µM), absolute salinity (g kg^{-1}), NH_4^+ (µM), ΔNO_3^- (µM), and ΔN_2O (nM) inside and outside the Puddies (mean state) on the S_{core} surface (σ_θ = 26.6 kg m^{-3}). $< >_{9-year}$ indicate the mean value of the corresponding variable in the corresponding region, while $< ' >$ the average value of the variable inside the Puddies (see Methods 2.3 and 2.6.1).

Zones	$< AOU >_{9-year}$	$< AOU' >$	$< S >_{9-year}$	$< S' >$	$< NH_4 >_{9-year}$	$< NH_4' >$	$< \Delta NO_3 >_{9-year}$	$< \Delta NO_3' >$	$< \Delta N_2O >_{9-year}$	$< \Delta N_2O' >$
NCZ	259.8±1	265.0±2	34.9±0.01	34.9±0.01	0.06±0.007	0.11±0.026	17.85±0.1	18.3±0.7	28.79±1	33.4±2
NTZ	241.4±2	256.6±5	34.8±0.01	34.8±0.01	0.02±0.003	0.07±0.03	17.1±0.1	18.7±0.5	23.5±1	34.9±3
NOZ	202.0±22	223.9±23	34.5±0.06	34.7±0.07	0.01±0.0003	0.017±0.02	14.7±1.5	16.6±1.7	16.4±7	26.8±6
SOZ	124.2±40	180.5±31	34.2±0.08	34.5±0.08	0.01±0.001	0.02±0.01	9.5±2.9	13.6±2.3	5.4±7	17.0±8
STZ	208.1±3	236.8±15	34.6±0.01	34.6±0.009	0.02±0.003	0.06±0.03	15.4±0.2	17.6±1.2	24.5±1	33.8±6
SCZ	240.4±1	249.8±7	34.8±0.004	34.8±0.004	0.08±0.005	0.09±0.03	17.7±0.1	18.4±1	34.65±0.5	37.8±3

Table S2. Percentiles 50th, 75th, and 90th (P50, P75, P90) of AOU (µM), absolute salinity (g kg^{-1}), NH_4^+ (µM), ΔNO_3^- (µM), and ΔN_2O (nM) on the S_{core} surface (σ_θ = 26.6 kg m^{-3}). The profiles were obtained from random samples (# pro.) using Montecarlo's method, for each region.

	#	AOU			S			NH_4^+			ΔNO_3^-			ΔN_2O		
Reg	pro.	**P50**	**P75**	**P90**	**P50**	**P75**	**P90**	**P50**	**P75**	**P90**	**P50**	**P75**	**P90**	**P50**	**P75**	**P90**
NCZ	**1246**	257	266	269	34.72	34.77	34.79	0.06	0.12	0.17	18.08	18.47	18.87	32.48	35.6	39.56
NTZ	**1474**	244	254	261	34.6	34.64	34.69	0.009	0.019	0.048	16.98	17.92	18.61	25.28	32.24	37.78
NOZ	**3509**	209	224	239	34.48	34.53	34.58	0.002	0.004	0.008	14.38	15.84	17.2	15.7	23.03	29.66
SOZ	**6808**	72	95	121	34.12	34.16	34.22	0.006	0.009	0.013	5.58	7.74	9.60	-1.44	-1.11	1.77
STZ	**521**	222	236	248	34.49	34.55	34.6	0.018	0.033	0.054	16.36	17.52	18.52	29.07	34.96	41.13
SCZ	**235**	240	256	264	34.57	34.65	34.7	0.052	0.119	0.188	17.69	18.69	19.44	36.14	42.96	47.11