Supporting Information for "The impact of initial tracer profile on the exchange and on-shelf distribution of tracers induced by a submarine canyon"

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Introduction

This document contains supplementary material to the methods and results sections of the paper.

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Figure S1. Supplementary to the methods section we include a figure showing the location of the stations where measurements of nutrients, dissolved oxygen, dissolved inorganic carbon, methane and nitrous-oxide, used to generate the initial profiles of the simulations, were taken. These stations correspond to stations visited during research cruises on the West Coast of Vancouver Island: the Pathways Cruise 2013 (Klymak et al., 2013) and Line C cruises in May 2012, May 2013. Methane and nitrous-oxide profiles from Line C were provided by Dr. David Capelle and published in Capelle and Tortell (2016).

Initial tracer profiles used to initialize the 10 tracers simulated in the experiments come from bottle samples collected during the Pathways Cruise (2013) and cruises to Line C (2013 and 2012). Methane and nitrous-oxide profiles correspond to the mean values of profiles taken at stations in Line C, upstream of Barkley Canyon. All other tracers are mean values of profiles taken along the axis of Barkely Canyon during the Pathways Cruise.

Table S1. Supplementary to the results section we include the same tables as in the manuscript but for all the tracers simulated in the numerical experiments. In Table S1 we report the Mean net transport (NT), Mean NT relative to AST transport and canyon contribution to Mean NT for all the tracers. Also, the Maximum net transport (Max NT), the Maximum net transport relative to the AST experiment and the canyon contribution to this quantity. Tracer transport units (TU) for each tracer are μMm^{3}s^{-1} (Linear), PSU (salinity), μmol kg^{-1}m^{3}s^{-1} (Oxygen), μMm^{3}s^{-1} (Nitrate), μMm^{3}s^{-1} (DS), μMm^{3}s^{-1} (Phosphate), nMm^{3}s^{-1}, μmol (Nitrous-Oxide), nMm^{3}s^{-1}, μmol (Methane), kg^{-1}m^{3}s^{-1} (DIC) and kg^{-1}m^{3}s^{-1} (Total Alkalinity).

Movie S1. This movie shows the concentration (top panels) and near-bottom concentration (bottom panel) for the Astoria Canyon run with linear stratification (AST) as the upwelling event evolves. Top left and top right panels show alongshelf and cross-shelf sections of linear tracer concentration normalized by the initial concentration at shelf break depth. This cross-sections are located at the dashed lines in the bottom left panel. The bottom left panel shows the bottom concentration normalized by the initial concentration at shelf break depth close the shelf bottom. During the time dependent phase (spin-up of the shelf current) concentration near the canyon rim increases quickly. After day 4, concentration near the shelf, away from the canyon, slightly decreases because the canyon suppresses shelf-break upwelling, but the concentration near the rim and downstream keeps increasing.

Movie S2. This movie shows the relative increase in concentration and near-bottom concentration from the no-canyon case as the upwelling event evolves in the Astoria canyon run with linear stratification (AST). Top left and top right panels show alongshelf and cross-shelf sections of linear tracer concentration anomaly (canyon minus no-canyon case) normalized by the initial concentration at shelf break depth. This cross-sections are located at the dashed lines in the bottom left panel. The bottom left panel shows the bottom concentration anomaly normalized by the initial concentration at each cell close the shelf bottom. Compared to the no-canyon case, during the time dependent phase (spin-up of the shelf current) a large pool of tracer with higher-than-background concentrations upwells onto the shelf. This pool is sustained and fed by the upwelling flux through the canyon and advected along the shelf during the advective phase (days 4-9).

References

Capelle, D. W., & Tortell, P. D. (2016). Factors controlling methane and nitrous-oxide variability in the southern British Columbia coastal upwelling system. *Mar. Chem.*, *179*, 56–67. doi: 10.1016/j.marchem.2016.01.011

Klymak, J., Dewey, R. K., Allen, S. E., & Waterman, S. (2013). *Pathways 2013 MVP cruise report* (Tech. Rep.).

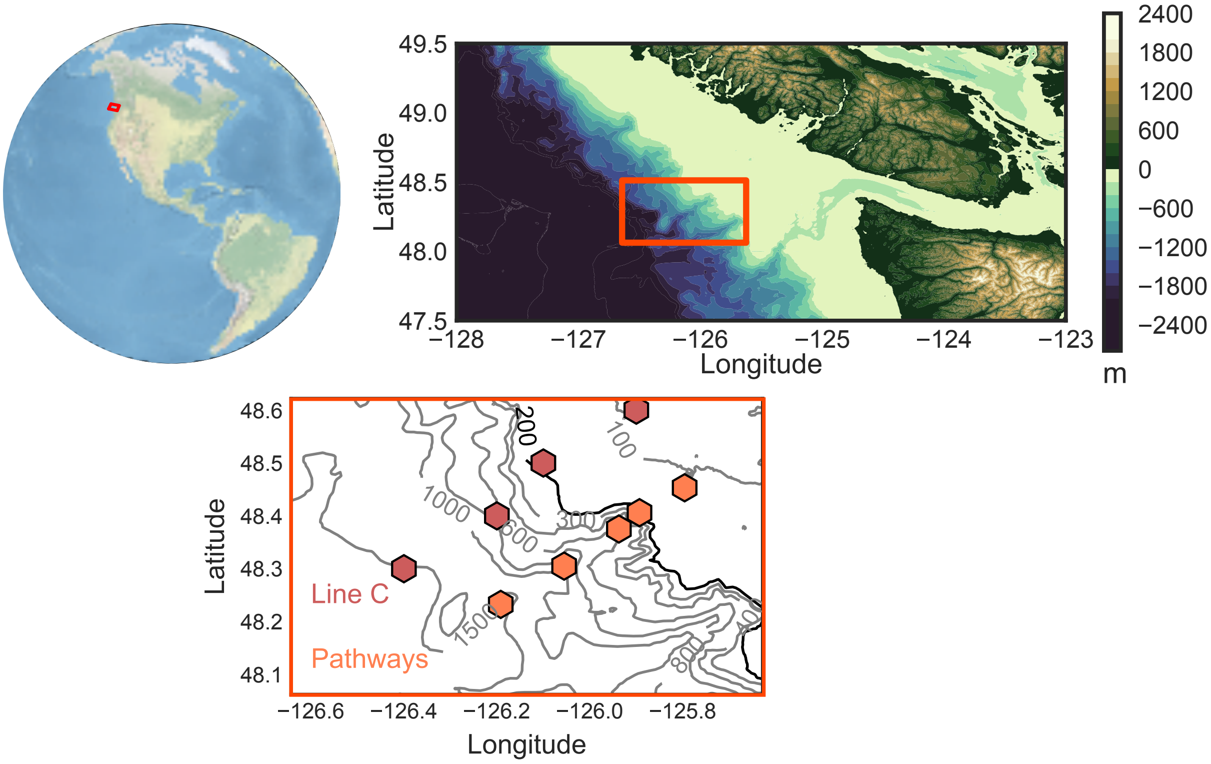

Figure S1. Initial tracer profiles used to initialize the 10 tracers simulated in the experiments come from bottle samples collected during the Pathways Cruise (2013) and cruises to Line C (2013 and 2012). Methane and nitrous-oxide profiles correspond to the mean values of profiles taken at stations in Line C, upstream of Barkley Canyon. All other tracers are mean values of profiles taken along the axis of Barkely Canyon during the Pathways Cruise. The location of the stations in Line C and Pathways Cruise are shown as orange and red pentagons, respectively.

Table S1. Tracer transport units (TU) for each tracer are μMm^{3}s^{-1}, PSU, μmol kg^{-1}m^{3}s^{-1}, μMm^{3}s^{-1}, μMm^{3}s^{-1}, μMm^{3}s^{-1}, nMm^{3}s^{-1}, μmol, nMm^{3}s^{-1}, μmol, kg^{-1}m^{3}s^{-1} and kg^{-1}m^{3}s^{-1}, respectively

Exp	Mean NT (10^4 TU)	Mean NT relative to AST (%)	Canyon contribution %	Max NT (10^4 TU)	Max NT relative to AST (%)	Canyon contribution %
AST Lin	50.60 ± 3.39	100.00	52.63	83.16	100.00	80.22
ARGO Lin	37.66 ± 1.95	74.42	37.21	57.74	69.43	65.04
BAR Lin	28.08 ± 1.02	55.49	6.84	33.66	40.48	18.69
PATH Lin	32.99 ± 1.52	65.19	12.00	40.46	48.66	24.26
AST Sal	21.38 ± 1.38	100.00	77.60	24.90	100.00	82.06
ARGO Sal	15.65 ± 1.65	73.22	75.38	20.03	80.43	74.54
BAR Sal	5.36 ± 0.28	25.05	35.87	8.31	33.37	47.43
PATH Sal	5.05 ± 0.28	23.63	31.50	8.59	34.49	43.87
AST Oxy	-644.88 ± 26.01	100.00	31.74	-60.75	100.00	36.40
ARGO Oxy	-515.14 ± 16.44	79.88	15.75	-59.71	98.29	32.58
BAR Oxy	-380.74 ± 14.00	59.04	1.89	-35.42	58.31	8.37
PATH Oxy	-429.55 ± 22.55	66.61	5.63	-38.77	63.82	9.33
AST Nit	114.02 ± 5.01	100.00	42.94	168.29	100.00	76.90
ARGO Nit	89.50 ± 4.25	78.50	29.49	127.77	75.92	57.22
BAR Nit	56.54 ± 2.01	49.59	6.35	67.53	40.13	17.74
PATH Nit	62.63 ± 3.26	54.93	8.36	78.44	46.61	18.78
AST DS	201.53 ± 10.64	100.00	47.22	309.21	100.00	78.80
ARGO DS	154.76 ± 7.54	76.79	33.05	227.39	73.54	60.38
BAR DS	103.80 ± 3.94	51.50	6.71	124.82	40.37	18.37
PATH DS	118.83 ± 5.88	58.96	10.59	147.42	47.68	21.45
AST Pho	8.27 ± 0.33	100.00	40.76	12.15	100.00	75.62
ARGO Pho	6.56 ± 0.30	79.28	27.29	9.34	76.87	55.32
BAR Pho	4.08 ± 0.15	49.30	5.92	4.87	40.12	17.00
PATH Pho	4.52 ± 0.24	54.60	7.99	5.69	46.83	17.31
AST NiO	0.09 ± 0.00	100.00	37.26	0.13	100.00	72.24
ARGO NiO	0.07 ± 0.00	80.72	24.08	0.10	78.36	53.64
BAR NiO	0.04 ± 0.00	47.40	5.54	0.05	36.60	16.34
PATH NiO	0.04 ± 0.00	50.61	6.36	0.05	40.85	16.40
AST Met	0.19 ± 0.02	100.00	58.51	0.37	100.00	87.36
ARGO Met	0.14 ± 0.01	71.73	42.20	0.25	66.57	80.92
BAR Met	0.14 ± 0.01	71.28	4.55	0.17	46.86	17.45
PATH Met	0.15 ± 0.01	78.04	6.78	0.19	52.37	20.35
AST DIC	1928.11 ± 123.58	100.00	67.93	2377.00	100.00	85.76
ARGO DIC	1433.05 ± 128.13	74.32	61.23	1856.88	78.12	63.55
BAR DIC	664.44 ± 31.00	34.46	20.80	906.65	38.14	34.43
PATH DIC	686.47 ± 36.08	35.60	19.25	981.69	41.30	32.83
AST Alk	1453.89 ± 98.06	100.00	79.03	1709.11	100.00	84.45
ARGO Alk	1054.76 ± 110.26	72.55	77.15	1352.24	79.12	76.07
BAR Alk	374.98 ± 20.13	25.79	35.18	576.91	33.76	47.25
PATH Alk	365.87 ± 19.21	25.16	31.50	604.85	35.39	45.33

Table S2. Pool area normalized by canyon area at day 9, maximum pool area, mean and maximum pool concentrations and maximum change in concentration from initial concentration. Concentration units are: μM, PSU, μmol/kg, μM, μM, μM, nM, nM, μmol/kg, μmol/kg.

Tracer	A_{pool}/A_{can} at day 9	max (A_{pool}/A_{can})	C at day 9	max C	max ΔC (%)
AST Lin	38.9	38.9	8.3	9.2	28.1
ARGO Lin	22.8	22.8	8.3	8.7	20.7
BAR Lin	6.6	11.2	9.8	9.9	10.3
PATH Lin	23.5	23.5	10.1	10.4	15.4
AST Sal	3.8	10.7	33.9	33.9	0.1
ARGO Sal	2.7	7.1	33.9	33.9	0.1
BAR Sal	3.4	7.8	33.9	34.0	0.0
PATH Sal	7.9	15.0	34.0	34.0	0.1
AST Oxy	35.3	35.3	96.2	86.7	-16.7
ARGO Oxy	20.4	20.4	95.5	90.8	-12.7
BAR Oxy	1.9	6.5	79.4	79.4	-6.4
PATH Oxy	5.7	11.0	75.7	75.7	-10.7
AST Nit	37.0	37.0	33.7	34.9	6.9
ARGO Nit	21.9	21.9	33.8	34.3	5.2
BAR Nit	3.1	7.7	35.7	35.8	2.4
PATH Nit	9.2	14.6	36.1	36.1	3.5
AST DS	35.3	35.3	50.2	52.9	11.1
ARGO DS	19.8	19.8	50.4	51.5	8.1
BAR DS	4.4	8.8	54.7	54.9	4.6
PATH DS	17.0	18.0	55.6	56.2	6.9
AST Pho	35.9	35.9	2.3	2.4	6.2
ARGO Pho	20.5	20.5	2.3	2.3	4.6
BAR Pho	2.4	6.9	2.4	2.4	2.0
PATH Pho	8.4	12.6	2.5	2.5	3.2
AST NiO	1.5	6.5	28.1	28.1	1.6
ARGO NiO	1.2	4.4	28.2	28.2	1.8
BAR NiO	5.3	10.4	28.1	28.2	0.6
PATH NiO	9.5	19.0	28.2	28.2	0.8
AST Met	47.3	47.3	25.6	32.4	85.4
ARGO Met	32.9	32.9	24.9	29.6	69.2
BAR Met	0.6	5.0	38.6	38.9	7.1
PATH Met	1.2	7.5	38.4	39.2	8.1
AST DIC	16.8	21.8	2233.4	2242.6	1.0
ARGO DIC	10.2	11.6	2234.7	2238.3	0.8
BAR DIC	2.7	9.4	2249.3	2249.5	0.3
PATH DIC	7.8	15.8	2253.2	2253.3	0.4
AST Alk	9.0	16.7	2264.3	2265.3	0.3
ARGO Alk	6.0	8.2	2264.4	2264.4	0.3
BAR Alk	7.1	11.4	2267.0	2267.5	0.2
PATH Alk	27.1	27.1	2267.6	2269.5	0.3

Table S3. Column 2: Mean tracer upwelling flux for selected tracers during the advective phase (days 4-9), reported with 12-h standard deviations. Columns 3 and 4: Tracer inventory or anomaly of total tracer mass on shelf and percentage relative to no-canyon case.

Run and tracer	$\Phi_{Tr}/10^9$ μmol s^{-1}	$(\mathcal{M}-\mathcal{M}_{nc})/$ 10^{12} μmol	$(\mathcal{M}-\mathcal{M}_{nc})/$ $(\mathcal{M}_{nc}-\mathcal{M}_{nc0})$ (%)
AST Lin	0.81±0.08	212.65	145.51
ARGO Lin	0.47±0.05	106.97	72.62
BAR Lin	0.15±0.04	16.04	9.80
PATH Lin	0.24±0.04	31.98	17.55
AST Sal	2.84±0.25	19.77	64.96
ARGO Sal	1.62±0.21	9.77	31.57
BAR Sal	0.49±0.14	0.99	4.86
PATH Sal	0.74±0.14	1.49	6.69
AST Oxy	7.06±0.54	-2564.56	96.16
ARGO Oxy	3.97±0.62	-1298.71	47.95
BAR Oxy	1.13±0.33	-161.16	6.84
PATH Oxy	1.63±0.33	-282.37	10.93
AST Nit	2.94±0.27	355.22	88.24
ARGO Nit	1.69±0.20	177.23	42.96
BAR Nit	0.51±0.14	22.38	6.80
PATH Nit	0.79±0.14	38.34	10.53
AST DS	4.51±0.42	717.68	109.96
ARGO DS	2.59±0.30	360.42	54.28
BAR DS	0.80±0.21	49.61	8.18
PATH DS	1.26±0.22	95.35	14.16
AST Pho	0.20±0.02	24.85	79.03
ARGO Pho	0.12±0.01	12.32	38.52
BAR Pho	0.04±0.01	1.52	6.68
PATH Pho	0.05±0.01	2.61	10.38
AST NiO	0.00±0.00	0.25	72.27
ARGO NiO	0.00±0.00	0.12	35.48
BAR NiO	0.00±0.00	0.01	5.01
PATH NiO	0.00±0.00	0.02	7.20
AST Met	0.00±0.00	0.98	203.54
ARGO Met	0.00±0.00	0.52	109.44
BAR Met	0.00±0.00	0.07	7.84
PATH Met	0.00±0.00	0.11	11.52
AST DIC	187.55±16.44	3493.10	88.96
ARGO DIC	107.20±13.74	1756.05	43.99
BAR DIC	32.26±8.98	208.60	6.42
PATH DIC	49.17±8.97	360.50	10.14
AST Alk	189.44±16.53	1636.70	85.54
ARGO Alk	108.22±13.93	821.13	42.73
BAR Alk	32.52±9.06	101.28	6.88
PATH Alk	49.52±9.04	177.60	10.96