

**Table 1.** Cost function values, including total cost and the costs for each assimilate observation type, before and after data assimilation. 3 modeling sites are Arabian Sea (AS), Equatorial Pacific (EQP) and Hawaii Ocean Time-series Station ALOHA (HOT).

Observation Type	AS		EQP		HOT	
	Before	After	Before	After	Before	After
Nitrate	167.95	8.68	16.66	5.38	2.22	2.06
Phosphate	84.13	2.70	7.66	4.00	1.36	0.65
Mesozooplankton C	9.89	1.10	19.74	5.31	19.96	1.05
Phytoplankton N	79.20	37.86	78.18	16.24	1.13	0.95
Chlorophyll <i>a</i>	29.58	4.23	83.75	11.88	180.04	10.42
Primary Production	411.60	10.91	278.02	19.29	2041.63	25.54
Bacterial C	259.50	5.76	7.14	1.09	22.89	13.48
Bacterial Production	17.37	7.01	9.23	3.26	14.60	2.02
Semilabile DOC	38.92	4.17	53.94	8.26	167.23	1.29
Semilabile DON	13.27	2.02			323.85	5.08
Semilabile DOP					96.96	0.93
POC	20.16	2.43	9.66	3.40	1703.82	2.56
PON	15.98	4.82	60.86	10.92	2744.97	1.49
POP			0.00		83.66	3.05
Sediment Trap C	102.58	5.57	8.75	2.76	93.22	0.74
Sediment Trap N	114.12	4.97	9.06	3.30	145.17	0.77
Sediment Trap P					1.30	0.42
Total	1364.24	102.24	642.65	95.07	7644.01	72.50

**Table 2.** Model parameter values, and optimized model parameter values after data assimilation. Also the confidence ranges of optimized parameters (if constrained) and gradients of parameters with respect to the cost function after data assimilation. The “Marks” indicates if the parameter was constrained (CS), adjusted but not constrained (AJ) or not adjusted (empty) by data assimilation. Please see model description for parameter definitions and units.

**(a) ARABIAN SEA (AS):**

Parameter Symbol	Default Value	Optimized Value	Confidence Range	Gradient	Marks
$A_E$	4000	4000.0		0.3530	
$\mu_{PHY}$	3.5	6.4211	5.58 – 7.40	-0.1060	CS
$\alpha_{PHY}^{CHL}$	2.0	0.4322	0.397 – 0.471	-0.2900	CS
$\beta_{PHY}$	0.002	0.0020		-0.7980	
$v_{REF,PHY}^N$	0.3	0.3000		-1.8800	
$k_{PHY}^{NH4}$	0.25	0.2500		1.6200	
$k_{PHY}^{NO3}$	1.0	1.2500		-0.3680	AJ
$v_{REF,PHY}^P$	0.02	0.0200		-1.5600	
$k_{PHY}^{PO4}$	0.06	0.0600		0.1630	
$\zeta^{NO3}$	2.0	2.0000		1.2800	
$\theta$	2.0	0.8799	0.748 – 1.04	-0.1540	CS
$ex_{PSV,PHY}$	0.05	0.0500		2.4900	
$ex_{CHO,PHY}$	0.05	0.0500		-1.0000	
$pom_{PHY}$	0.04	0.0227	0.0185 – 0.0278	-0.0191	CS
$\mu_{TR}$	3.0	N/A		N/A	
$\alpha_{TR}^{CHL}$	0.15	N/A		N/A	
$\beta_{TR}$	0.002	N/A		N/A	
$v_{REF,TR}^N$	0.4	N/A		N/A	
$k_{TR}^{NH4}$	0.05	N/A		N/A	
$k_{TR}^{NO3}$	0.5	N/A		N/A	
$v_{REF,TR}^P$	0.02	N/A		N/A	
$k_{TR}^{PO4}$	0.047	N/A		N/A	
$pick_{TR}^{PO4}$	1.0	N/A		N/A	
$\zeta^{NFIX}$	2.5	N/A		N/A	
$ex_{PSV,TR}$	0.02	N/A		N/A	
$ex_{NFIX,TR}$	0.36	N/A		N/A	
$ex_{CHO,TR}$	0.05	N/A		N/A	
$pom_{TR}$	0.08	N/A		N/A	
$\mu_{UN}$	1.6	N/A		N/A	
$\alpha_{UN}^{CHL}$	0.5	N/A		N/A	

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$k_{DOM}$	0.5	0.5000		0.6320	
$b_{LABI,N}$	5.0	6.8000		0.0000	AJ
$b_{LABI,P}$	5.6	5.3741	5.08 – 5.69	-0.0571	CS
$\mu_{BA}$	2.0	1.1395	0.984 – 1.32	0.0545	CS
$b_{RESP}$	0.28	0.2800		0.1660	
$ex_{ADJ,BA}$	2.0	2.0000		0.0000	
$remi_{BA}$	6.0	6.0000		0.5370	
$ex_{REFR,BA}$	0.018	0.0310		1.0500	AJ
$f_{SLCT,BA}$	0.25	0.2500		-0.5520	
$resp_{BA}^B$	0.01	0.0100		0.0627	
$r_{min,BA}^A$	0.35	0.3500		-0.1670	
$r_{max,BA}^A$	0.80	0.6948	0.636 – 0.759	-0.0480	CS
$mort_{BA}$	0.021	0.0310		0.3340	AJ
$\mu_{PRT}$	2.0	0.9931	0.758 – 1.30	0.4860	CS
$g_{PHY}$	0.67	3.0442	2.67 – 3.47	-0.3470	CS
$g_{BA}$	1.0	2.0196	1.70 – 2.39	0.0452	CS
$ex_{PRT}$	0.20	0.2000		0.3660	
$f_{ex,PRT}$	0.75	0.7500		-0.1830	
$resp_{PRT}^B$	0.01	0.0100		0.0750	
$resp_{PRT}^A$	0.67	0.3243	0.217 – 0.485	-0.1820	CS
$ex_{ADJ,PRT}$	2.0	2.0000		-0.0106	
$remi_{PRT}$	4.0	4.0000		-0.1800	
$pom_{PRT}$	0.027	0.0280		0.1490	AJ
$\mu_{MZ}$	1.3	1.1316	1.02 – 1.26	-0.7600	CS
$g_{PRT}$	0.65	1.4645	1.13 – 1.90	0.4670	CS
$g_{TR}$	2.0	2.0000		0.0000	
$ex_{MZ}$	0.20	0.2000		2.0400	
$f_{ex,MZ}$	0.75	0.7500		-1.2400	
$resp_{MZ}^B$	0.03	0.0300		0.3590	
$resp_{MZ}^A$	0.25	0.2500		1.5500	
$ex_{ADJ,MZ}$	2.0	2.0000		0.0000	
$remi_{MZ}$	4.0	4.0000		-0.1490	
$pom_{MZ}$	0.12	0.1200		1.2000	

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$ex_{REFR,MZ}$	0.02	0.0200		0.2870	
$remv_{MZ}$	0.81	0.3800		1.9800	AJ
$f_{SDOM,HZ}$	0.2	0.1400		0.5530	AJ
$f_{POM,HZ}$	0.2	0.0940		0.7240	AJ
$ex_{REFR,SDOM}$	0.0009	0.0009		0.2840	
$q_{N,REFR}^C$	0.05	0.0500		1.3600	
$q_{P,REFR}^C$	0.0007	0.0007		-0.2950	
$q_{N,POM}^C$	0.12	0.1200		3.9900	
$q_{P,POM}^C$	0.01	0.0100		-2.2900	
$r_{ntf}$	0.15	0.1500		-1.0400	
$prf_N$	1.05	1.0500		-1.0100	
$prf_P$	1.10	1.1000		2.3400	
$wnsV$	30.0	30.0000		-1.8200	
$diss$	0.1	0.1192	0.112 – 0.147	0.0318	CS

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**(b) Equatorial Pacific (EQP):**

Parameter Symbol	Default Value	Optimized Value	Confidence Range	Gradient	Marks
$A_E$	4000	2000.0		5.6500	AJ
$\mu_{PHY}$	3.5	3.4436	3.12 – 3.80	0.2910	CS
$\alpha_{PHY}^{CHL}$	2.0	1.7479	1.52 – 2.01	0.1650	CS
$\beta_{PHY}$	0.001	0.0010		-1.8800	
$v_{REF,PHY}^N$	0.3	0.3278	0.282 – 0.380	0.2990	CS
$k_{PHY}^{NH4}$	0.25	0.1900		0.7680	AJ
$k_{PHY}^{NO3}$	4.0	4.0000		-5.8200	
$v_{REF,PHY}^P$	0.02	0.0140		-0.9730	AJ
$k_{PHY}^{PO4}$	0.1	0.1000		0.0954	
$\zeta^{NO3}$	2.0	2.0000		-0.4200	
$\theta$	2.0	3.4000		-3.5800	AJ
$ex_{PSV,PHY}$	0.05	0.0500		0.8550	
$ex_{CHO,PHY}$	0.05	0.0500		-1.2700	
$pom_{PHY}$	0.04	0.1300		-0.9440	AJ
$\mu_{TR}$	3.0	N/A		N/A	
$\alpha_{TR}^{CHL}$	0.15	N/A		N/A	
$\beta_{TR}$	0.002	N/A		N/A	
$v_{REF,TR}^N$	0.4	N/A		N/A	
$k_{TR}^{NH4}$	0.05	N/A		N/A	
$k_{TR}^{NO3}$	0.5	N/A		N/A	
$v_{REF,TR}^P$	0.02	N/A		N/A	
$k_{TR}^{PO4}$	0.047	N/A		N/A	
$pick_{TR}^{PO4}$	1.0	N/A		N/A	
$\zeta^{NFIX}$	2.5	N/A		N/A	
$ex_{PSV,TR}$	0.02	N/A		N/A	
$ex_{NFIX,TR}$	0.36	N/A		N/A	
$ex_{CHO,TR}$	0.05	N/A		N/A	
$pom_{TR}$	0.08	N/A		N/A	
$\mu_{UN}$	1.6	N/A		N/A	
$\alpha_{UN}^{CHL}$	0.5	N/A		N/A	

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$k_{DOM}$	0.5	0.5500		0.0126	AJ
$b_{LABI,N}$	5.0	5.2000		0.0000	AJ
$b_{LABI,P}$	5.6	8.2426	6.81 – 9.98	0.6020	CS
$\mu_{BA}$	2.0	2.9224	1.74 – 4.90	-0.2090	CS
$b_{RESP}$	0.15	0.1500		-0.6530	
$ex_{ADJ,BA}$	2.0	2.0000		0.0001	
$remi_{BA}$	6.0	6.0000		-0.8400	
$ex_{REFR,BA}$	0.02	0.0200		0.1130	
$f_{SLCT,BA}$	0.25	0.2500		-0.3250	
$resp_{BA}^B$	0.01	0.0100		0.0565	
$r_{min,BA}^A$	0.35	0.3500		0.4380	
$r_{max,BA}^A$	0.80	0.8755	0.835 – 0.912	1.6800	CS
$mort_{BA}$	0.02	0.0200		-0.0995	
$\mu_{PRT}$	2.0	1.0986	0.944 – 1.28	-0.1560	CS
$g_{PHY}$	0.67	0.8992	0.846 – 0.956	0.3720	CS
$g_{BA}$	1.0	1.5737	1.16 – 2.14	-0.2240	CS
$ex_{PRT}$	0.20	0.2000		-0.8930	
$f_{ex,PRT}$	0.75	0.7500		1.3900	
$resp_{PRT}^B$	0.01	0.0100		3.6000	
$resp_{PRT}^A$	0.67	0.5819	0.544 – 0.623	0.5720	CS
$ex_{ADJ,PRT}$	2.0	2.0000		0.0000	
$remi_{PRT}$	4.0	4.0000		0.4440	
$pom_{PRT}$	0.027	0.0260		-0.1080	AJ
$\mu_{MZ}$	1.3	1.2381	0.937 – 1.64	0.0719	CS
$g_{PRT}$	2.0	1.5984	1.29 – 1.98	-0.2000	CS
$g_{TR}$	1.0	1.0000		0.0000	
$ex_{MZ}$	0.20	0.2000		-0.2030	AJ
$f_{ex,MZ}$	0.75	0.7500		-0.2000	
$resp_{MZ}^B$	0.03	0.0300		0.6140	
$resp_{MZ}^A$	0.25	0.4461	0.379 – 0.525	-0.3880	CS
$ex_{ADJ,MZ}$	2.0	2.0000		0.0000	
$remi_{MZ}$	4.0	4.0000		-0.0769	
$pom_{MZ}$	0.1	0.1000		-0.2200	

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$ex_{REFR,MZ}$	0.02	0.0200		0.0200	
$remv_{MZ}$	0.8	0.2000		0.2640	AJ
$f_{SDOM,HZ}$	0.2	0.2000		-0.0572	
$f_{POM,HZ}$	0.2	0.3500		-0.0713	
$ex_{REFR,SDOM}$	0.0009	0.0009		0.3510	
$q_{N,REFR}^C$	0.05	0.0500		1.0400	
$q_{P,REFR}^C$	0.0007	0.0007		0.0035	
$q_{N,POM}^C$	0.12	0.1200		0.2090	
$q_{P,POM}^C$	0.01	0.0100		-0.3930	
$r_{ntf}$	0.15	0.1700		-1.2600	AJ
$prf_N$	1.1	1.1000		10.1000	
$prf_P$	1.1	2.0352	1.37 – 3.03	-0.0634	CS
$wnsv$	30.0	30.0000		0.9050	
$diss$	0.1	0.1563	0.150 – 1.63	0.1290	CS

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**(c) Hawaii Ocean Time-series Station ALOHA (HOT):**

Parameter Symbol	Default Value	Optimized Value	Confidence Range	Gradient	Marks
$A_E$	4000	4000.0		-0.1780	
$\mu_{PHY}$	3.5	2.2286	1.77 – 2.81	-0.4010	CS
$\alpha_{PHY}^{CHL}$	2.0	4.5589	3.34 – 6.21	-0.0805	CS
$\beta_{PHY}$	0.001	0.0010		4.8200	
$v_{REF,PHY}^N$	0.3	0.3000		1.2800	
$k_{PHY}^{NH4}$	0.01	0.0100		1.0600	
$k_{PHY}^{NO3}$	0.1	0.1000		-1.0600	
$v_{REF,PHY}^P$	0.02	0.0091	0.0067 – 0.0123	-0.0015	CS
$k_{PHY}^{PO4}$	0.0048	0.0048		0.0307	
$\zeta^{NO3}$	2.0	2.0000		-0.4300	
$\theta$	2.0	2.2373	1.79 – 2.80	-0.0270	CS
$ex_{PSV,PHY}$	0.05	0.0500		2.6300	
$ex_{CHO,PHY}$	0.05	0.0500		0.8030	
$pom_{PHY}$	0.038	0.0380		1.4100	
$\mu_{TR}$	3.0	3.0000		-0.8510	
$\alpha_{TR}^{CHL}$	0.25	0.2500		0.0535	
$\beta_{TR}$	0.002	0.0020		1.0600	
$v_{REF,TR}^N$	0.4	0.4000		1.8600	
$k_{TR}^{NH4}$	0.05	0.0500		-0.9000	
$k_{TR}^{NO3}$	0.5	0.5000		-0.2440	
$v_{REF,TR}^P$	0.02	0.0200		-0.0373	
$k_{TR}^{PO4}$	0.047	0.0470		0.0251	
$pick_{TR}^{PO4}$	1.0	1.0000		0.0118	
$\zeta^{NFIX}$	2.5	2.5000		1.0800	
$ex_{PSV,TR}$	0.02	0.0200		0.5380	
$ex_{NFIX,TR}$	0.36	0.3600		-0.3160	
$ex_{CHO,TR}$	0.05	0.0500		0.2540	
$pom_{TR}$	0.1	0.0800		0.0545	AJ
$\mu_{UN}$	1.6	1.6000		-4.5200	
$\alpha_{UN}^{CHL}$	0.5	0.5000		-0.6750	

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$k_{DOM}$	0.5	0.5000		0.0586	
$b_{LABI,N}$	10.0	10.0000		-0.0002	
$b_{LABI,P}$	10.0	8.8497	8.55 – 9.16	-0.1630	CS
$\mu_{BA}$	2.0	2.0000		0.3750	
$b_{RESP}$	0.28	0.2800		0.5170	
$ex_{ADJ,BA}$	2.0	2.0000		0.0000	
$remi_{BA}$	6.0	6.0000		0.0902	
$ex_{REFR,BA}$	0.02	0.0180		0.7940	AJ
$f_{SLCT,BA}$	0.2	0.2000		-0.8410	
$resp_{BA}^B$	0.01	0.0100		0.4300	
$r_{min,BA}^A$	0.35	0.3500		-0.6580	
$r_{max,BA}^A$	0.80	0.6380	0.604 – 0.674	-0.0115	CS
$mort_{BA}$	0.02	0.0490		1.2100	AJ
$\mu_{PRT}$	2.0	4.0000		-4.9100	
$g_{PHY}$	0.67	0.7987	0.674 – 0.946	-0.0550	CS
$g_{BA}$	2.0	2.0000		4.8700	
$ex_{PRT}$	0.20	0.2000		5.2100	
$f_{ex,PRT}$	0.80	0.8000		-11.9000	
$resp_{PRT}^B$	0.01	0.0100		1.1300	
$resp_{PRT}^A$	0.67	0.7532	0.746 – 0.761	-0.7100	CS
$ex_{ADJ,PRT}$	2.0	2.0000		0.1190	
$remi_{PRT}$	4.7	4.7000		-1.3200	
$pom_{PRT}$	0.027	0.0270		1.1200	
$\mu_{MZ}$	1.0	1.3000		0.0816	AJ
$g_{PRT}$	0.65	1.6957	1.29 – 2.22	0.0020	CS
$g_{TR}$	1.0	0.2345	0.207 – 0.265	0.0282	CS
$ex_{MZ}$	0.20	0.3000		1.1000	
$f_{ex,MZ}$	0.75	0.7500		-2.6700	
$resp_{MZ}^B$	0.03	0.0300		0.0676	
$resp_{MZ}^A$	0.25	0.2229		-1.1500	AJ
$ex_{ADJ,MZ}$	2.0	2.0000		0.0000	
$remi_{MZ}$	4.0	4.0000		-0.0856	
$pom_{MZ}$	0.15	0.1500		0.2040	

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$ex_{REFR,MZ}$	0.02	0.0200		-0.1010	
$remv_{MZ}$	0.8	0.8100		-0.3820	AJ
$f_{SDOM,HZ}$	0.1	0.1000		0.4610	
$f_{POM,HZ}$	0.2	0.1400		0.5000	AJ
$ex_{REFR,SDOM}$	0.0009	0.0009		-1.6000	
$q_{N,REFR}^C$	0.05	0.0500		-4.2700	
$q_{P,REFR}^C$	0.0007	0.0007		0.0050	
$q_{N,POM}^C$	0.12	0.1200		3.4100	
$q_{P,POM}^C$	0.0045	0.0045		-0.0731	
$r_{ntf}$	0.1	0.1000		-0.8160	
$prf_N$	1.1	1.1000		1.0200	
$prf_P$	4.0	4.0000		-1.3700	
$wnsv$	2.0	5.0487	3.62 – 7.03	-0.0147	CS
$diss$	0.02	0.0131	0.0081 – 0.0211	0.0142	CS

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