1 Parametrisation

The tables below specify the parametrisation used for all simulations described in the "Implementations" section of the paper and in the test harness example. Each parameter appears under the namelist file and namelist identifier that contain it, stating its name in the code, the mathematical symbol used for it in the paper, a description, its unit and its value.

1.1 bacteria.nml: bacteriaParameters

Code ID	Symbol	Description	Unit	Value
chB1nX	$h^{B}_{\mathbb{N}}$	Michaelis-Menten constant for nitrogen limitationof bacteria	$mmol * m^{-3}$	0.5
chB1pX	$h^{B}_{\mathbb{P}}$	Michaelis-Menten constant for phosphorus limitationof bacteria	$mmol * m^{-3}$	0.1
chdB1oX	$h^{B}_{\mathbb{O}}$	Michaelis-Menten constant for oxygen limitation of bacteria relative to saturation state	1	0.31
chN3oX	$h^{nitr}_{\mathbb{O}}$	Cubic Michaelis-Menten constant for oxygenic control of nitrification	$mmol^3 * m^{-9}$	2700.
chN4nX	$h^{nitr}_{\mathbb{N}}$	Cubic Michaelis-Menten constant for ammonium limitation of nitrification	$mmol^3 * m^{-9}$	.5
frB1R3	q_{srefr}	Bacteria uptake converted to semi-refractory DOC in proportion to activity respiration	1	0.3
fsinkX	$r_{\mathbb{F}scav}$	Specific scavenging rate for iron	d^{-1}	0.00007
puB1oX	$h^{B}_{low\mathbb{O}}$	Bacterial efficiency at low oxygen levels	1	0.2
puB1X	$h^{B}_{high\mathbb{O}}$	Bacterial efficiency at high oxygen levels	1	0.6
puR4_B1X	r^{slab}_{small}	Turn-over of small POM relative to DOM	d^{-1}	1.E-2

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Table 1 – continued from previous page

Code ID	Symbol	Description	Unit	Value
puR6_B1X	r^{slab}_{med}	Turn-over of medium size POM relative to DOM	d^{-1}	1.E-2
puR8_B1X	r^{slab}_{large}	Turn-over of large POM relative to DOM	d^{-1}	1.E-2
q10B1X	$p^{B}_{Q_{10}}$	Regulating temperature factor Q10 for bacterial metabolic processes	1	2.
qnB1cX	$q^{B}_{max_{\mathbb{N}:\mathbb{C}}}$	Maximum N to C quota of bacteria	$mol * g^{-1}$	1.67E-2
qpB1cX	$q^{B}_{max_{\mathbb{P}:\mathbb{C}}}$	Maximum P to C quota Phosphate/Carbon of bacteria	$mol * g^{-1}$	1.9E-3
redfieldX	$q_{ref_{\mathbb{C}:\mathbb{N}}}$	C to N ratio (Redfield)	1	6.63
rR2B1X	$q_{\mathbf{M}}^{slab}$	Turn-over of semi-labile OM relative to DOM	1	7.5E-3
rR2R1X	r^{slab}_{decomp}	Specific rate for breakdown of semi-labile to labile DOC	d^{-1}	1.E-2
rR3B1X	$q_{\mathbf{M}}^{srefr}$	Turn-over of semi-refractory OM relative to DOM	1	2.5E-3
sdB1X	r^{B}_{mort}	Specific mortality of bacteria at reference temperature	d^{-1}	5.E-2
sN4N3X	r^{B}_{nitr}	Maximum specific nitrification rate at reference temperature	d^{-1}	.5
sR1N1X	$r_{rem_{\mathbb{P}}}$	Specific remineralisation of DOM to phosphate	d^{-1}	0.E0
sR1N4X	$r_{rem_{\mathbb{N}}}$	Specific remineralisation of DOM to ammonium	d^{-1}	0.E0
sR4R1	$q_{\mathbf{M}}^{small}$	Turn-over of small POM relative to DOM	1	1.E-2
sR6R1	$q_{\mathbf{M}}^{med}$	Turn-over of medium size POM relative to DOM	1	2.5E-3
sR8R1	$q_{\mathbf{M}}^{large}$	Turn-over of large POM relative to DOM	1	1.E-3
srsB1X	r^{B}_{mort}	Specific rest respiration of bacteria at reference temperature	d^{-1}	0.1
sumB1X	g^{B}_{max}	Max. specific uptake of bacteria at reference temperature	d^{-1}	2.2

1.2 benthicOldenburg.nml: BenthicOldenburgParameters

Code ID	Symbol	Description	Unit	Value
EDZ_1X	ϑ_{oxy}	Basal diffusivity of inorganics in aerobic layer	$m^2 * d^{-1}$	5.00E-05
EDZ_2X	ϑ_{denit}	Basal diffusivity of inorganics in anaerobic layer	$m^2 * d^{-1}$	5.00E-05
EDZ_3X	ϑ_{denit}	Basal diffusivity of inorganics in anoxic layer	$m^2 * d^{-1}$	5.00E-05
EDZ_mixX	p_{vmix}	Equilibrium diffusive speed between sediment surface water	$m * d^{-1}$	20.
hM3G4X	$h_{\mathbb{N}}^{denitr}$	Michaelis-Menten constant for benthic nitrate limitiation of nitrification	$mmol * m^{-3}$	1.
hM4M3X	$h_{\mathbb{N}}^{bnitr}$	Inhibition constant for oxidised nitrogen content at which denitrifacation is halfed	$mmol * m^{-3}$	10.
M11adsX	$p_{ads}^{\mathbb{P}}$	Phosphorus adsorption factor in anoxic layer	1	2.
M1adsX	$p_{ads}^{\mathbb{P}}$	Phosphorus adsorption factor in oxygenated and oxidsed layer	1	100.
M4adsX	p_{ads}^{amm}	Ammonium adsorption factor	1	3.
pammonX	q_{red}^{H}	Maximum fraction of anaerobic bacteria respiration resulting in oxidised nitrogen reduction	1	0.5
pdenitX	q_{denit}^{H}	Fraction of reduction subject to denitrification as opposed to ammonification	1	0.05
q10nitX	$p_{Q_{10}}^{bnitr}$	Regulating temperature factor Q10 for nitrification	1	2.
relax_mX	τ_{denit}	Oxidised nitrogen relaxation time scale	d^{-1}	5.
relax_oX	τ_{ox}	Oxygen relaxation time scale	d^{-1}	5.
sM4M3X	r_{nitr}^{H}	Specific nitrification rate	d^{-1}	4.
sQ6M5X	$r_{\mathbb{S}remin}$	Specific silicate regeneration rate	d^{-1}	7.00E-03

1.3 benthos.nml: benthosParameters

Code ID	Symbol	Description	Unit	Value
d_totX	d_{tot}	Total depth of benthic layer system	m	0.3
ddH1X	d_{ref}^{oxy}	Aerobic half saturation depth of bacterial uptake regulation	m^{-1}	1.00E-03
ddH2X	d_{ref}^{denit}	Anerobic half saturation depth of bacterial uptake regulation	m^{-1}	1.00E-02
dQ6Y2X	d_Y^{DEPO}	Lower depth limit of deposit feeders	m	0.3
dQ6Y3X	d_Y^{SUSP}	Lower depth limit of suspension feeders	m	2.50E-03
dQ6Y4x	d_Y^{MEIO}	Lower depth limit of meiobenthos	m	3.00E-02
dturX	δ_{bturb}	Bioturbation length scale	m	2.00E-02
dwatY3X	d_{SUSP}	Range of suspension feeders into the water column	m^{-1}	1.
EturX	ϑ_{part}	Basal diffusivity of particulate matter	$m^2 * d^{-1}$	2.00E-06
hirrX	h_{birr}	Half-saturation rate for bioirrigation enhancement	$mg * m^{-2} * d^{-1}$	101.
hO2Y2X	$h_{\mathbb{O}}^{DEPO}$	Half-saturation content for oxygen limitation of deposit feeders	$mmol * m^{-3}$	0.00E+00
hO2Y3X	$h_{\mathbb{O}}^{SUSP}$	Half-saturation content for oxygen limitation of suspension feeders	$mmol * m^{-3}$	0.00E+00
hO2Y4X	$h_{\mathbb{O}}^{MEIO}$	Half-saturation content for oxygen limitation of meiobenthos	$mmol * m^{-3}$	0.00E+00
hturX	h_{bturb}	Half-saturation rate for bioturbation enhancement	$mg * m^{-2} * d^{-1}$	116.
huY2X	f_{min}^{DEPO}	Food half-saturation content of the chance of encountering prey for deposit feeders	$mg * m^{-2}$	3000
huY3X	f_{min}^{SUSP}	Food half-saturation content of the chance of encountering prey for supension feeders	$mg * m^{-2}$	300.

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Code ID	Symbol	Description	Unit	Value
huY4X	f_{min}^{MEIO}	Food half-saturation content of the chance of encountering prey for meiobenthos	$mg*m^{-2}$	1000.
irr_minX	p_{bimin} :	Minimum diffusion enhancement through bio irrigation	1	2.
luY2X	h_{min}^{DEPO}	Food half-saturation content for detection of individual prey types by deposit feeders	$mg*m^{-2}$	250
luY3X	h_{min}^{SUSP}	Food half-saturation content for detection of individual prey types of supension feeders	$mg*m^{-2}$	10.
luY4X	h_{min}^{MEIO}	Food half-saturation content for detection of individual prey types of meiobenthos	$mg*m^{-2}$	50.
mirrX	p_{bienh}	Maximal bioirrigation enhancement	1	10
mturX	p_{btenh}	Maximal bioturbation enhancement	1	10.
pdH1Q1X	q^{aer}_{dmort}	Dissolved fraction of benthic aerobic bacteria mortality	1	0.1
pe_R1P1X	q^{dia}_{ddepo}	Fraction of deposited diatoms decomposing into DOM	1	0.2
pe_R1P2X	q^{nano}_{ddepo}	Fraction of deposited nanophytoplankton decomposing into DOM	1	0.5
pe_R1P3X	q^{pico}_{ddepo}	Fraction of deposited picophytoplankton decomposing into DOM	1	0.5
pe_R1P4X	q^{micro}_{ddepo}	Fraction of deposited microphytoplankton decomposing into DOM	1	0.5
pe_R7P1X	q^{dia}_{rdepo}	Fraction of deposited diatoms decomposing into refractory matter	1	5.00E-03
pe_R7P2X	q^{nano}_{rdepo}	Fraction of deposited nanophytoplankton decomposing into refractory matter	1	5.00E-02

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Code ID	Symbol	Description	Unit	Value
pe_R7P3X	q^{pico}_{rdepo}	Fraction of deposited nanophytoplankton decomposing into refractory matter	1	5.00E-02
pe_R7P4X	q^{micro}_{rdepo}	Fraction of deposited nanophytoplankton decomposing into refractory matter	1	5.00E-02
pe_R7R6X	q^{part}_{rdepo}	Fraction of deposited POM turning into refractory POM	1	0.1
pirrY2X	q^{DEPO}_{birr}	Fraction of deposit feeder uptake contributing to bioirrigation	1	1.
pirrY4X	q^{MEIO}_{birr}	Fraction of meiobenthos uptake contributing to bioirrigation	1	0.2
poroXr	p_{poro}	Porosity volume correction factor	1	0.4
pQIN3X	q^{ox}_{remin}	Fraction of remineralisation of benthic matter going to nitrate (benthic remineralisation submodel only)	1	0.9
pturY2X	q^{depo}_{bturb}	Fraction of deposit feeder uptake contributing to bioturbation	1	1.
pudilY2X	q^{DEPO}_{dil}	Relative nutrient content in the fecal pellets excreted by deposit feeders	1	0.8
pudilY3X	q^{SUSP}_{dil}	Relative nutrient content in the fecal pellets excreted by suspension feeders	1	0.8
pudilY4X	q^{MEIO}_{dil}	Relative nutrient content in the fecal pellets excreted by meiobenthos	1	0.8
pue6H1Q1X	q^{aer}_{dexcr}	Excreted fraction of uptake of POM by benthic aerobic bacteria	1	0.1
pue7H1Q1X	q^{aer}_{rexcr}	Excreted fraction of uptake of refractory matter by benthic aerobic bacteria	1	0.1

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Code ID	Symbol	Description	Unit	Value
pueQ6Y2X	q^{DEPO}_{pexcr}	Excreted fraction of uptake of particulate matter by deposit feeders	1	0.8
pueQ6Y3X	q^{SUSP}_{pexcr}	Excreted fraction of uptake of particulate matter by suspension feeders	1	0.85
pueQ6Y4X	q^{MEIO}_{pexcr}	Excreted fraction of uptake of particulate matter by suspension feeders	1	0.4
pueY2X	q^{DEPO}_{excr}	Excreted fraction of fixed uptake by deposit feeders	1	0.35
pueY3X	q^{SUSP}_{excr}	Excreted fraction of fixed uptake by suspension feeders	1	0.35
pueY4X	q^{MEIO}_{excr}	Excreted fraction of fixed uptake by meiobenthos	1	0.25
puH1Y2X	$f_{pr}\|^{Y^{DEPO}}_{H^{aer}}$	Food preference of deposit feeders for aerobic bacteria	1	1.
puH1Y3X	$f_{pr}\|^{Y^{SUSP}}_{H^{aer}}$	Food preference of suspension feeders for aerobic bacteria	1	1.
puH1Y4X	$f_{pr}\|^{Y^{MEIO}}_{H^{aer}}$	Food preference of meiobenthos for aerobic bacteria	1	1.
puH2Y2X	$f_{pr}\|^{Y^{DEPO}}_{H^{anaer}}$	Food preference of deposit feeders for anaerobic bacteria	1	1.
puH2Y4X	$f_{pr}\|^{Y^{MEIO}}_{H^{anaer}}$	Food preference of meiobenthos for anaerobic bacteria	1	1.
puincH1X	p^{aer}_{nup}	Preference factor for nutrient upatke by aerobic bacteria	1	2.
puincH2X	p^{anaer}_{nup}	Preference factor of nutrient uptake by anaerobic bacteria	1	2.
puP1Y3X	$f_{pr}\|^{Y^{SUSP}}_{P^{dia}}$	Food preference of suspension feeders for diatoms	1	1.
puP2Y3X	$f_{pr}\|^{Y^{SUSP}}_{P^{nano}}$	Food preference of suspension feeders for medium size phytoplnkton	1	1.

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Code ID	Symbol	Description	Unit	Value
puP3Y3X	$f_{pr}\vert_{P}^{pico}{}_{Y}^{SUSP}$	Food preference of suspension feeders for small size phytoplankton	1	1.
puQ6Y2X	$f_{pr}\vert_{Q}^{slow}{}_{Y}^{DEPO}$	Food preference of deposit feeders for POM	1	0.1
puQ6Y3X	$f_{pr}\vert_{Q}^{slow}{}_{Y}^{SUSP}$	Food preference of suspension feeders for benthic POM	1	0.1
puQ6Y4X	$f_{pr}\vert_{Q}^{slow}{}_{Y}^{MEIO}$	Food preference of meiobenthos for POM	1	0.3
puR6Y3X	$f_{pr}\vert_{R}^{med}{}_{Y}^{SUSP}$	Food preference of suspension feeders for medium size POM	1	1.
purH1X	q^{aer}_{aresp}	Fraction of carbon uptake respired by benthic aerobic bacetria	1	0.3
purH2X	q^{anaer}_{aresp}	Fraction of carbon uptake respired by benthic anaerobic bacetria	1	0.3
purY2X	q^{DEPO}_{aresp}	Respired fraction of uptake by deposit feeders	1	0.35
purY3X	q^{SUSP}_{aresp}	Respired fraction of uptake by suspension feeders	1	0.4
purY4X	q^{MEIO}_{aresp}	Respired fraction of uptake by meiobenthos	1	0.45
puY4Y2X	$f_{pr}\vert_{Y}^{MEIO}{}_{Y}^{DEPO}$	Food preference of deposit feeders for meiobenthos	1	1.
puY4Y4X	$f_{pr}\vert_{Y}^{MEIO}{}_{Y}^{MEIO}$	Food preference of meiobenthos for meiobenthos	1	1.
q10H1x	$p^{aer}_{Q_{10}}$	Regulating temperature factor Q10 for benthic aerobic bacteria	1	2.
q10H2X	$p^{anaer}_{Q_{10}}$	Regulating temperature factor Q10 for benthic anaerobic bacteria	1	2.
q10Y2X	$p^{DEPO}_{Q_{10}}$	Regulating temperature factor Q10 for deposit feeders	1	2.

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Code ID	Symbol	Description	Unit	Value
q10Y3X	$p^{SUSP}_{Q_{10}}$	Regulating temperature factor Q10 for suspension feeders	1	2.
q10Y4X	$p^{MEIO}_{Q_{10}}$	Regulating temperature factor Q10 for meiobenthos	1	2.
qnHIcX	$q^{H}_{ref_{\mathbb{N}:\mathbb{C}}}$	Nitrogen to carbon ratio of benthic bacteria	$mol * g^{-1}$	1.67E-02
qnYIcX	$q^{Y}_{ref_{\mathbb{N}:\mathbb{C}}}$	Nitrogen to carbon ratio of benthic fauna	$mol * g^{-1}$	1.19E-02
qpHIcX	$q^{H}_{ref_{\mathbb{P}:\mathbb{C}}}$	Phosphorus to carbon ratio of benthic bacteria	$mol * g^{-1}$	1.25E-03
qpYIcX	$q^{Y}_{ref_{\mathbb{P}:\mathbb{C}}}$	Phosphorus to carbon ratio of benthic fauna	$mol * g^{-1}$	7.92E-04
reminQ1X	r^{dis}_{remin}	Remineralisation rate of DOM (benthic remineralisation model only)	d^{-1}	0.1
reminQ6X	r^{slow}_{remin}	Remineralisation rate of slowly degradable matter (benthic remineralisation model only)	d^{-1}	5.00E-02
reminQ7X	r^{refr}_{remin}	Remineralistion rate of refractory matter (benthic remineralisation model only)	d^{-1}	1.00E-02
rlO2Y2x	$p^{DEPO}_{\mathbb{O}min}$	Minimum oxygen treshold of deposit feeders	$mmol * m^{-3}$	0.00E+00
rlO2Y3X	$p^{SUSP}_{\mathbb{O}min}$	Minimum oxygen treshold of suspension feeders	$mmol * m^{-3}$	0.00E+00
rlO2Y4X	$p^{MEIO}_{\mathbb{O}min}$	Minimum oxygen treshold of meiobenthos	$mmol * m^{-3}$	0.00E+00
sdcY2X	r^{DEPO}_{mortT}	Specific mortality of deposit feeders induced at cold temperature	d^{-1}	2.20E-02
sdcY3X	r^{SUSP}_{mortT}	Specific mortality of suspension feeders induced at cold temperature	d^{-1}	2.20E-02
sdcY4X	r^{MEIO}_{mortT}	Specific mortality of meiobenthos induced at cold temperature	d^{-1}	2.00E-02
sdH1X	r^{aer}_{mort}	Specific maximal mortality of benthic aerobic bacteria	d^{-1}	5.00E-02

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Table 3 – continued from previous page

Code ID	Symbol	Description	Unit	Value
sdH2X	r_{mort}^{anaer}	Specific maximal mortality of benthic anaerobic bacteria	d^{-1}	5.00E-02
sdmO2Y2X	$r^{DEPO}_{mort\mathbb{O}}$	Specific maximal additional mortality of deposit feeders due to oxygen stress	d^{-1}	1.
sdmO2Y3X	$r^{SUSP}_{mort\mathbb{O}}$	Specific maximal additional mortality of suspension feeders due to oxygen stress	d^{-1}	1.
sdmO2Y4X	$r^{MEIO}_{mort\mathbb{O}}$	Specific maximal additional mortality of meiobenthos due to oxygen stress	d^{-1}	1.
sdY2X	r_{mort}^{DEPO}	Specific mortality of deposit feeders at reference temperature	d^{-1}	1.00E-03
sdY3X	r_{mort}^{DEPO}	Specific mortality of suspension feeders at reference temperature	d^{-1}	1.00E-03
sdY4X	r_{mort}^{DEPO}	Specific mortality of meiobenthos at reference temperature	d^{-1}	1.00E-02
srH1X	r^{aer}_{resp}	Specific rest respiration of benthic aerobic bacetria	d^{-1}	2.00E-02
srH2X	r^{anaer}_{resp}	Specific rest respiration of benthic anaerobic bacetria	d^{-1}	2.00E-02
srY2X	r^{DEPO}_{resp}	Specific rest respiration of deposit feeders at reference temperature	d^{-1}	2.70E-03
srY3X	r^{SUSP}_{resp}	Specific rest respiration of suspension feeders at reference temperature	d^{-1}	2.70E-03
srY4X	r^{MEIO}_{resp}	Specific rest respiration of meiobenthos at reference temperature	d^{-1}	1.00E-02
suQ1H1X	$r_{up}\|^{\overset{aer}{H}}_{\underset{Q}{dis}}$	Specific DOC uptake by benthic aerobic bacteria	$m^3 * mg^{-1} * d^{-1}$	5.00E-04
suQ6fH1X	$r_{fast}\|^{\overset{aer}{H}}_{\underset{Q}{slow}}$	Specific fast nutrient limited detritus uptake by benthic aerobic bacteria	$m^3 * mg^{-1} * d^{-1}$	2.00E-04

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Table 3 – continued from previous page

Code ID	Symbol	Description	Unit	Value
suQ6fH2X	$r_{fast}\|_{slow\,Q}^{anaer\,H}$	Specific fast nutrient limited POM uptake by benthic anaerobic bacteria	$m^3 * mg^{-1} * d^{-1}$	2.00E-04
suQ6sH1X	$r_{up}\|_{slow\,Q}^{aer\,H}$	Specific not nutrient limited detritus uptake by benthic aerobic bacteria	$m^3 * mg^{-1} * d^{-1}$	2.00E-05
suQ6sH2X	$r_{up}\|_{slow\,Q}^{anaer\,H}$	Specific not nutrient limited POM uptake by benthic anaerobic bacteria	$m^3 * mg^{-1} * d^{-1}$	2.00E-05
suQ7H1X	$r_{up}\|_{refr\,Q}^{aer\,H}$	Specific not nutrient limited refractory matter uptake by benthic aerobic bacteria	$m^3 * mg^{-1} * d^{-1}$	2.00E-06
suQ7H2X	$r_{up}\|_{refr\,Q}^{anaer\,H}$	Specific not nutrient limited refractory matter uptake by benthic anaerobic bacteria	$m^3 * mg^{-1} * d^{-1}$	2.00E-06
suY2X	g_{max}^{DEPO}	Specific maximal uptake by deposit feeders at reference temperature	d^{-1}	0.11
suY3X	g_{max}^{SUSP}	Specific maximal uptake by suspension feeders at reference temperature	d^{-1}	9.00E-02
suY4X	g_{max}^{MEIO}	Specific maximal uptake of meiobenthos at reference temperature	d^{-1}	0.4
xchY2X	h_{crowd}^{DEPO}	Concentration determining asymptotic treshold of crowding limitation of deposit feeders	$mg * m^{-2}$	5000
xchY3X	h_{crowd}^{SUSP}	Concentration determining asymptotic treshold of shading limitation of suspension feeders	$mg * m^{-2}$	5000.
xclY2X	$p_{\mathbb{C}}^{DEPO}$	Lower treshold for crowding effect on food uptake by deposit feeders	$mg * m^{-2}$	2500
xclY3X	$p_{\mathbb{C}}^{SUSP}$	Lower treshold for shading effect on food uptake by suspension feeders	$mg * m^{-2}$	2500.

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Table 3 – continued from previous page

Code ID	Symbol	Description	Unit	Value
xcsY2X	h_{sat}^{DEPO}	Michaelis-Menten constant for the impact of crowding on deposit feeders	$mg * m^{-2}$	3000
xcsY3X	h_{sat}^{SUSP}	Michaelis-Menten constant for the impact of crowding on suspension feeders	$mg * m^{-2}$	3000.
xdcY2X	$\frac{1}{T_{cold}^{DEPO}}$	e-folding temperature factor of cold mortality response of deposit feeders	$°C^{-1}$	-0.7
xdcY3X	$\frac{1}{T_{cold}^{SUSP}}$	e-folding temperature factor of cold mortality response of suspension feeders	$°C^{-1}$	-0.7
xdcY4X	$\frac{1}{T_{cold}^{MEIO}}$	e-folding temperature factor of cold mortality response of meiobenthos	$°C^{-1}$	-0.7

1.4 calc.nml: calcParameters

Code ID	Symbol	Description	Unit	Value
bendiss	r^{calc}_{remin}	Dissolution rate in the sediments	d^{-1}	0.05
gutdiss	$q_{gutdiss}$	Fraction of excreted zooplankton uptake of nanophytoplankton contributing to calcification	1	0.5
KcalomX	h_{calc}	Half-saturation constant for calcification limitation from saturation state	1	0.40
ncalc	n_{calc}	Power of the calcification law	1	0.81
ndiss	n_{dis}	Power of the dissolution law	1	2.22
Rain0	q_{rain0}	Max rain ratio	1	0.6
sedL2	p	Sedimentation velocity of free liths	$m * d^{-1}$	10.0
sL2O3X	r_{dis}	Maximum specific dissolution rate	d^{-1}	0.03

1.5 d3morf.nml: d3morfParameters

Code ID	Symbol	Description	Unit	Value
EPS0Xr	Λ_{sea}	Light extinction of (pure) seawater	m^{-1}	4.00E-02

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Table 5 – continued from previous page

Code ID	Symbol	Description	Unit	Value
EPSESSX	$\lambda_{R_{susp}}$	Specific light extinction of silt	m^2mg^{-2}	4.00E-05
EPSP1X	λ_{P}^{dia}	Specific light extinction of diatoms	m^2mg^{-2}	5.00E-04
EPSP2X	λ_{P}^{nano}	Specific light extinction of medium size phytoplanton	m^2mg^{-2}	4.00E-04
EPSP3X	λ_{P}^{pico}	Specific light extinction of picophytoplankton	m^2mg^{-2}	4.00E-04
EPSP4X	λ_{P}^{micro}	Specific light extinction of microphytoplankton	m^2mg^{-2}	4.00E-04
EPSR6X	λ_R	Specific light extinction of medium size POM	m^2mg^{-2}	1.00E-04

1.6 fmatrix.nml: fmatrixParameters

Code ID	Symbol	Description	Unit	Value
suB1_Z4X	$f_{pr}\big\|_{B}^{Z^{MESO}}$	Food preference of mesozooplankton for bacteria	1	0.E0
suB1_Z5X	$f_{pr}\big\|_{B}^{Z^{MICRO}}$	Food preference of microzooplankton for bacteria	1	.1E0
suB1_Z6X	$f_{pr}\big\|_{B}^{Z^{HET}}$	Food preference of heteroflagellates for bacteria	1	.45E0
suP1_Z4X	$f_{pr}\big\|_{P^{dia}}^{Z^{MESO}}$	Food preference of mesozooplankton for diatoms	1	.15E0
suP1_Z5X	$f_{pr}\big\|_{P^{dia}}^{Z^{MICRO}}$	Food preference of microzooplankton for diatoms	1	.15E0
suP2_Z4X	$f_{pr}\big\|_{P^{nano}}^{Z^{MESO}}$	Food preference of mesozooplankton for nanophytoplankton	1	0.05E0
suP2_Z5X	$f_{pr}\big\|_{P^{nano}}^{Z^{MICRO}}$	Food preference of microzooplankton for nanophytoplankton	1	.15E0
suP2_Z6X	$f_{pr}\big\|_{P^{nano}}^{Z^{HET}}$	Food preference of heteroflagellates for nanophytoplankton	1	.15E0
suP3_Z4X	$f_{pr}\big\|_{P^{pico}}^{Z^{MESO}}$	Food preference of mesozooplankton for picophytoplankton	1	0.E0
suP3_Z5X	$f_{pr}\big\|_{P^{pico}}^{Z^{MICRO}}$	Food preference of microzooplankton for picophytoplankton	1	.15E0

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Table 6 – continued from previous page

Code ID	Symbol	Description	Unit	Value
suP3_Z6X	$f_{pr}\big\|_{P^{pico}}^{Z^{HET}}$	Food preference of heteroflagellates for picophytoplankton	1	.25E0
suP4_Z4X	$f_{pr}\big\|_{P^{micro}}^{Z^{MESO}}$	Food preference of mesozooplankton for microphytoplankton	1	.15E0
suP4_Z5X	$f_{pr}\big\|_{P^{micro}}^{Z^{MICRO}}$	Food preference of microzooplankton for microphytoplankton	1	.1E0
suR6_Z4X	$f_{pr}\big\|_{R^{med}}^{Z^{HET}}$	Food preference of mesozooplankton for medium size POM	1	.1E0
suZ4_Z4X	$f_{pr}\big\|_{Z^{MESO}}^{Z^{MESO}}$	Food preference of mesozooplankton for mesozooplankton	1	.25E0
suZ5_Z4X	$f_{pr}\big\|_{Z^{MICRO}}^{Z^{MESO}}$	Food preference of mesozooplankton for microzooplanton	1	.25E0
suZ5_Z5X	$f_{pr}\big\|_{Z^{MICRO}}^{Z^{MICRO}}$	Food preference of microzooplankton for microzooplankton	1	.15E0
suZ6_Z4X	$f_{pr}\big\|_{Z^{HET}}^{Z^{MESO}}$	Food preference of mesozooplankton for heteroflagellates	1	.05E0
suZ6_Z5X	$f_{pr}\big\|_{Z^{HET}}^{Z^{MICRO}}$	Food preference of microzooplankton for heteroflagellates	1	.2E0
suZ6_Z6X	$f_{pr}\big\|_{Z^{HET}}^{Z^{HET}}$	Food preference of heteroflagellates for heteroflagellates	1	.15E0

1.7 heterotrophic_nanoflagellate.nml: heterotrophic_nanoflagellate_parameters

Code ID	Symbol	Description	Unit	Value
chrZ6oX	$h_{\mathbb{O}}^{HET}$	Saturation constant for oxygen limitation of heteroflagellates	1	7.81
chuZ6cX	h_{up}^{HET}	Predation efficiency constant limiting the chances of encountering prey for heteroflagellates	$mg * m^{-3}$	28.
minfoodZ6X	h_{min}^{HET}	Michaelis-Menten constant to perceive food for heteroflagellates	$mg * m^{-3}$	12.

Continued on next page

Table 7 – continued from previous page

Code ID	Symbol	Description	Unit	Value
pe_R1Z6X	q^{HET}_{dloss}	DOM-Fraction of heteroflagellate excretion and mortality	1	0.5
pu_eaZ6X	q^{HET}_{excr}	Excreted fraction of uptake by heteroflagellates	1	0.5
puZ6X	q^{HET}_{eff}	Relative heteroflagellates assimilation efficiency	1	0.4
q10Z6X	$p^{HET}_{Q_{10}}$	Regulating temperature factor Q10 for heteroflagellates	1	2.
qnZ6cX	$q^{HET}_{ref_{\mathbb{N}:\mathbb{C}}}$	Maximal nitrogen to carbon ratio of heteroflagellates	$mol * g^{-1}$	1.67E-02
qpZ6cX	$q^{HET}_{ref_{\mathbb{P}:\mathbb{C}}}$	Maximal phosphorus to carbon ratio of heteroflagellates	$mol * g^{-1}$	1.00E-03
sdZ6oX	$p^{HET}_{mort\mathbb{O}}$	Specific mortality of heteroflagellates due to oxygen limitation	d^{-1}	0.3
sdZ6X	p^{HET}_{mort}	Specific basal mortality of heteroflagellates	d^{-1}	5.00E-02
srsZ6X	r^{HET}_{resp}	Specific rest respiration of heteroflagellates at reference temperature	d^{-1}	2.50E-02
stempZ6nX	$r^{HET}_{rel\mathbb{N}}$	Specific ammonium excretion rate of heteroflagellates	d^{-1}	0.5
stempZ6pX	$r^{HET}_{rel\mathbb{P}}$	Specific phosphate excretion rate of heteroflagellates	d^{-1}	0.5
sumZ6X	g^{HET}_{max}	Maximal specific uptake of heteroflagellates at reference temperature	d^{-1}	1.5

1.8 iop.nml: iopParameters

Code ID	Symbol	Description	Unit	Value
a0w	a_{sea}	Adsorption coefficient of clear water	m^{-1}	.03
adR4	$a^{*}_{\substack{small\\R}}$	Specific adsorption coefficient of small POC	m^2mg^{-2}	1.e-5
adR6	$a^{*}_{\substack{med\\R}}$	Specific adsorption coefficient of medium POC	m^2mg^{-2}	1.e-5
adR8	$a^{*}_{\substack{large\\R}}$	Specific adsorption coefficient of large POC	m^2mg^{-2}	1.e-5

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Table 8 – continued from previous page

Code ID	Symbol	Description	Unit	Value
aphP1	$a^{*}_{P\ dia}$	Specific adsorption coefficient of diatoms	m^2mg^{-2}	.007
aphP2	$a^{*}_{P\ nano}$	Specific adsorption coefficient of nanophytoplankton	m^2mg^{-2}	.0041
aphP3	$a^{*}_{P\ pico}$	Specific adsorption coefficient of picophytoplankton	m^2mg^{-2}	.023
aphP4	$a^{*}_{P\ micro}$	Specific adsorption coefficient of microphytoplankton	m^2mg^{-2}	.008
b0w	b_{sea}	Backscattering coefficient of clear water	m^{-1}	.0015
bbR4	$b^{*}_{R\ small}$	Specific backscattering coefficient of small POC	m^2mg^{-2}	1.6e-5
bbR6	$b^{*}_{R\ med}$	Specific backscattering coefficient of medium POC	m^2mg^{-2}	1.6e-5
bbR8	$b^{*}_{R\ large}$	Specific backscattering coefficient of large POC	m^2mg^{-2}	1.6e-5
bphP1	$b^{*}_{P\ dia}$	Specific backscattering coefficient of diatoms	m^2mg^{-2}	.00048
bphP2	$b^{*}_{P\ nano}$	Specific backscattering coefficient of nanophytoplankton	m^2mg^{-2}	.003
bphP3	$b^{*}_{P\ pico}$	Specific backscattering coefficient of picophytoplankton	m^2mg^{-2}	.003
bphP4	$b^{*}_{P\ micro}$	Specific backscattering coefficient of microphytoplankton	m^2mg^{-2}	.00048

1.9 mesozoo.nml: mesozooParameters

Code ID	Symbol	Description	Unit	Value
chrZ4oX	$h^{MESO}_{\mathbb{O}}$	Saturation constant for oxygen limitation of mesozooplankton	1	7.81
chuZ4cX	h^{MESO}_{up}	Predation efficiency constant limiting the chances of encountering prey for heteroflagellates	$mg * m^{-3}$	36.
minfoodZ4X	h^{MESO}_{min}	Michaelis-Menten constant to perceive food for mesozooplankton	$mg * m^{-3}$	12.
pe_R1Z4X	q^{MESO}_{dloss}	DOM-fraction of mesozooplankton excretion and mortality	1	0.5
pu_eaRZ4X	q^{MESO}_{Rexcr}	Excreted fraction of POM uptake by mesozooplankton	1	0.9

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Table 9 – continued from previous page

Code ID	Symbol	Description	Unit	Value
pu_eaZ4X	q^{MESO}_{excr}	Excreted fraction of uptake by mesozooplantkon	1	0.5
puZ4X	q^{MESO}_{eff}	Relative mesoplankton assimilation efficiency	1	0.6
q10Z4X	$p^{MESO}_{Q_{10}}$	Regulating temperature factor Q10 for mesozooplankton	1	2.
sdZ4oX	$p^{MESO}_{mort\mathbb{O}}$	Specific mortality of mesozooplantkon due to oxygen limitation	d^{-1}	0.2
sdZ4X	p^{MESO}_{mort}	Specific basal mortality of mesozooplankton	d^{-1}	5.00E-02
srsZ4X	r^{MESO}_{resp}	Specific rest respiration of mesozooplankton at reference temperature	d^{-1}	1.50E-02
sumZ4X	g^{MESO}_{max}	Maximal specific uptake of mesozooplankton at reference temperature	d^{-1}	1.
Z4mortX	r_{owmort}	Specific overwintering mortality of mesozooplankton	d^{-1}	2.50E-03
Z4repwX	r_{owresp}	Specific overwintering respiration of mesozooplankton	d^{-1}	2.50E-03

1.10 microzoo.nml: microzooParameters

Code ID	Symbol	Description	Unit	Value
chrZ5oX	$h^{MICRO}_{\mathbb{O}}$	Saturation constant for oxygen limitation of microzooplankton	1	7.81
chuZ5cX	h^{MICRO}_{up}	Predation efficiency constant limiting the chances of encountering prey for microzooplankton	$mg * m^{-3}$	32.
minfoodZ5X	h^{MICRO}_{min}	Michaelis-Menten constant to perceive food for microzooplankton	$mg * m^{-3}$	12.
pe_R1Z5X	q^{MICRO}_{dloss}	DOM-Fraction of microzooplankton excretion and mortality	1	0.5

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Table 10 – continued from previous page

Code ID	Symbol	Description	Unit	Value
pu_eaZ5X	q^{MICRO}_{excr}	Excreted fraction of uptake by microzooplankton	1	0.5
puZ5X	q^{MICRO}_{eff}	Relative microplankton assimilation efficiency	1	0.5
q10Z5X	$p^{MICRO}_{Q_{10}}$	Regulating temperature factor Q10 for microzooplankton	1	2.
qnZ5cX	$q^{MICRO}_{ref_{\mathbb{N}:\mathbb{C}}}$	Maximal nitrogen to carbon ratio of microzooplankton	$mol * g^{-1}$	1.67E-02
qpZ5cX	$q^{MICRO}_{ref_{\mathbb{P}:\mathbb{C}}}$	Maximal phosphorus to carbon ratio of microzooplankton	$mol * g^{-1}$	1.00E-03
sdZ5oX	$p^{MICRO}_{mort\mathbb{O}}$	Specific mortality of microzooplantkon due to oxygen limitation	d^{-1}	0.25
sdZ5X	p^{MICRO}_{mort}	Specific basal mortality of microzooplankton	d^{-1}	5.00E-02
srsZ5X	r^{MICRO}_{resp}	Specific rest respiration of microzooplankton at reference temperature	d^{-1}	2.00E-02
stempZ5nX	$r^{MICRO}_{rel\mathbb{N}}$	Specific ammonium excretion rate of microozooplankton	d^{-1}	0.5
stempZ5pX	$r^{MICRO}_{rel\mathbb{P}}$	Specific phosphate excretion rate of microozooplankton	d^{-1}	0.5
sumZ5X	g^{MICRO}_{max}	Maximal specific uptake of microzooplankton at reference temperature	d^{-1}	1.25

1.11 ox.nml: oxParameters

Code ID	Symbol	Description	Unit	Value
pco2a3	$p^{air}_{CO_2}$	Partial pressure of atmospheric CO2	ppm	385.

1.12 pel.nml: pelParameters

Code ID	Symbol	Description	Unit	Value
MinpreyX	p^{ow}_{min}	Food treshold for overwintering state of zoolplankton	$mg * m^{-2}$	300.

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Table 12 – continued from previous page

Code ID	Symbol	Description	Unit	Value
qnZIcX	$q^{MESO}_{\mathbb{N}:\mathbb{C}}$	Fixed nitrogen to carbon ratio of mesozooplankton	$mol * g^{-1}$	1.26E-2
qpZIcX	$q^{MESO}_{\mathbb{P}:\mathbb{C}}$	Fixed phosphate to carbon ratio of mesozooplankton	$mol * g^{-1}$	7.86E-4
R1R2X	q_{lab}	Labile fraction of DOM production	1	1.
uB1c_O2X	$p^{syn}_{\mathbb{O}}$	Conversion of carbon into oxygen produced	$mol * g^{-1}$	0.11
urB1_O2X	$p^{resp}_{\mathbb{O}}$	Conversion of carbon into oxygen respired	$mol * g^{-1}$	0.1
xR1nX	$p^{lab}_{cyto_{\mathbb{N}}}$	Nitrogen fraction in cytoplasm of DOM vs. structural components	1	1.
xR1pX	$p^{lab}_{cyto_{\mathbb{P}}}$	Phosphorus fraction in cytoplasm of DOM vs. structural components	1	1.2
xR7nX	$p^{part}_{cyto_{\mathbb{N}}}$	Nitrogen fraction in cytoplasm of POM vs. structural components	1	1.
xR7pX	$p^{part}_{cyto_{\mathbb{P}}}$	Phosphorus fraction in cytoplasm of POM vs. structural components	1	0.6

1.13 primary_producers.nml: primary_producer_parameters

Code ID	Symbol	Description	Unit	Value
alphaP1X	α^{dia}_{PI}	Initial slope of PI-curve for diatoms	$mg * m^2 * W^{-1} * d^{-1}$	4.
alphaP2X	α^{nano}_{PI}	Initial slope of PI-curve for nanophytoplankton	$mg * m^2 * W^{-1} * d^{-1}$	5.
alphaP3X	α^{pico}_{PI}	Initial slope of PI-curve for picophytoplankton	$mg * m^2 * W^{-1} * d^{-1}$	6.
alphaP4X	α^{micro}_{PI}	Initial slope of PI-curve for microphytoplankton	$mg * m^2 * W^{-1} * d^{-1}$	3.
betaP1X	β^{dia}_{PI}	Photo-inhibition paramter for diatoms	$mg * m^2 * W^{-1} * d^{-1}$	7.E-2
betaP2X	β^{nano}_{PI}	Photo-inhibition paramter for nanophytoplankton	$mg * m^2 * W^{-1} * d^{-1}$	1.E-1

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Table 13 – continued from previous page

Code ID	Symbol	Description	Unit	Value
betaP3X	β^{pico}_{PI}	Photo-inhibition paramter for picophytoplankton	$mg * m^2 * W^{-1} * d^{-1}$	1.2E-1
betaP4X	β^{micro}_{PI}	Photo-inhibition paramter for microphytoplankton	$mg * m^2 * W^{-1} * d^{-1}$	6.E-2
chP1sX	$h^{dia}_{\mathbb{S}}$	Michaelis-Menten constant for Silicate limitation	$mmol * m^{-3}$	.2
esNIP1X	p^{dia}_{sink}	Level of nutrient limitation below which diatoms subside	1	0.7
esNIP2X	p^{nano}_{sink}	Level of nutrient limitation below which nanophytoplankton subsides	1	0.7
esNIP3X	p^{pico}_{sink}	Level of nutrient limitation below which picophytoplankton subsides	1	0.7
esNIP4X	p^{micro}_{sink}	Level of nutrient limitation below which microphytoplankton subsides	1	0.7
peir_eowX	q_{PAR}	photosynthetically available fraction of irradiation	1	0.5
phimP1X	$q^{dia}_{\varphi max}$	Maximal effective chlorophyll to carbon photosynthesis ratio of diatoms	1	6.E-2
phimP2X	$q^{nano}_{\varphi max}$	Maximal effective chlorophyll to carbon photosynthesis ratio of nanophytoplankton	1	2.5E-2
phimP3X	$q^{pico}_{\varphi max}$	Maximal effective chlorophyll to carbon photosynthesis ratio of picophytoplankton	1	1.5E-2
phimP4X	$q^{micro}_{\varphi max}$	Maximal effective chlorophyll to carbon photosynthesis ratio of microphytoplankton	1	4.5E-2
pu_eaP1X	q^{dia}_{excr}	Excreted fraction of primary production by diatoms	1	0.2
pu_eaP2X	q^{nano}_{excr}	Excreted fraction of primary production by nanophytoplankton	1	0.2

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Table 13 – continued from previous page

Code ID	Symbol	Description	Unit	Value
pu_eaP3X	q^{pico}_{excr}	Excreted fraction of primary production by picophytoplankton	1	0.2
pu_eaP4X	q^{micro}_{excr}	Excreted fraction of primary production by microphytoplankton	1	0.2
pu_raP1X	q^{dia}_{aresp}	Respired fraction of primary production by diatoms (activity respiration)	1	0.2
pu_raP2X	q^{nano}_{aresp}	Respired fraction of primary production by nanophytoplankton (activity respiration)	1	0.2
pu_raP3X	q^{pico}_{aresp}	Respired fraction of primary production by picophytoplankton (activity respiration)	1	0.2
pu_raP4X	q^{micro}_{aresp}	Respired fraction of primary production by microphytoplankton (activity respiration)	1	0.2
q10P1X	$p^{dia}_{Q_{10}}$	Regulating temperature factor Q10 for diatoms	1	2.
q10P2X	$p^{nano}_{Q_{10}}$	Regulating temperature factor Q10 for nanophytoplankton	1	2.
q10P3X	$p^{pico}_{Q_{10}}$	Regulating temperature factor Q10 for picophytoplankton	1	2.
q10P4X	$p^{micro}_{Q_{10}}$	Regulating temperature factor Q10 for microphytoplankton	1	2.
qflP1cX	$q^{dia}_{min_{\mathbb{F}:\mathbb{C}}}$	Minimal iron to carbon ratio of diatoms	μmol $*$ mg^{-1}	5.E-5
qflP2cX	$q^{nano}_{min_{\mathbb{F}:\mathbb{C}}}$	Minimal iron to carbon ratio of nanophytoplankton	μmol $*$ mg^{-1}	1.E-4
qflP3cX	$q^{pico}_{min_{\mathbb{F}:\mathbb{C}}}$	Minimal iron to carbon ratio of picophytoplankton	μmol $*$ mg^{-1}	1.5E-4
qflP4cX	$q^{micro}_{min_{\mathbb{F}:\mathbb{C}}}$	Minimal iron to carbon ratio of microphytoplankton	μmol $*$ mg^{-1}	5.E-5
qfRP1cX	$q^{dia}_{ref_{\mathbb{F}:\mathbb{C}}}$	Maximal/optimal iron to carbon ratio of diatoms	μmol $*$ mg^{-1}	5.E-4
qfRP2cX	$q^{nano}_{min_{\mathbb{F}:\mathbb{C}}}$	Maximal/optimal iron to carbon ratio of nanophytoplankton	μmol $*$ mg^{-1}	3.E-4

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Table 13 – continued from previous page

Code ID	Symbol	Description	Unit	Value
qfRP3cX	$\overset{pico}{q}_{min_{\mathbb{F}:\mathbb{C}}}$	Maximal/optimal iron to carbon ratio of picophytoplankton	$\mu mol * mg^{-1}$	5.E-4
qfRP4cX	$\overset{micro}{q}_{min_{\mathbb{F}:\mathbb{C}}}$	Maximal/optimal iron to carbon ratio of microphytoplankton	$\mu mol * mg^{-1}$	5.E-4
qnlP1cX	$\overset{dia}{q}_{min_{\mathbb{N}:\mathbb{C}}}$	Minimal nitrogen to carbon ratio for diatoms	$mol * g^{-1}$	4.2E-3
qnlP2cX	$\overset{nano}{q}_{min_{\mathbb{N}:\mathbb{C}}}$	Minimal nitrogen to carbon ratio for nanophytoplankton	$mol * g^{-1}$	5.E-3
qnlP3cX	$\overset{pico}{q}_{min_{\mathbb{N}:\mathbb{C}}}$	Minimal nitrogen to carbon ratio for picophytoplankton	$mol * g^{-1}$	6.E-3
qnlP4cX	$\overset{micro}{q}_{min_{\mathbb{N}:\mathbb{C}}}$	Minimal nitrogen to carbon ratio for microphytoplankton	$mol * g^{-1}$	4.2E-3
qnRPIcX		Inverse Redfield ratio of nitrogen to carbon	$mol * g^{-1}$	1.26E-2
qplP1cX	$\overset{dia}{q}_{min_{\mathbb{P}:\mathbb{C}}}$	Minimal phosphorus to carbon ratio for diatoms	$mol * g^{-1}$	1.E-4
qplP2cX	$\overset{nano}{q}_{min_{\mathbb{P}:\mathbb{C}}}$	Minimal phosphorus to carbon ratio for nanophytoplankton	$mol * g^{-1}$	2.25E-4
qplP3cX	$\overset{pico}{q}_{min_{\mathbb{P}:\mathbb{C}}}$	Minimal phosphorus to carbon ratio for picophytoplankton	$mol * g^{-1}$	3.5E-4
qplP4cX	$\overset{micro}{q}_{min_{\mathbb{P}:\mathbb{C}}}$	Minimal phosphorus to carbon ratio for microphytoplankton	$mol * g^{-1}$	1.E-4
qpRPIcX		Inverse Redfield ratio of Phosphorus to carbon	$mol * g^{-1}$	7.86E-4
qsP1cX	$\overset{dia}{q}_{ref_{\mathbb{S}:\mathbb{C}}}$	Maximal silicon to carbon ratio of diatoms	$mol * g^{-1}$	1.18E-2
quP1n3X	$\overset{dia}{r}_{aff_n}$	Nitrate affinity of diatoms	$m^3 * mg^{-1} * d^{-1}$	2.5E-3
quP1n4X	$\overset{dia}{r}_{aff_a}$	Ammonium affinity of diatoms	$m^3 * mg^{-1} * d^{-1}$	2.5E-3
quP2n3X	$\overset{nano}{r}_{aff_n}$	Nitrate affinity of nanophytoplankton	$m^3 * mg^{-1} * d^{-1}$	4.E-3
quP2n4X	$\overset{nano}{r}_{aff_a}$	Ammonium affinity of nanophytoplankton	$m^3 * mg^{-1} * d^{-1}$	4.E-3
quP3n3X	$\overset{pico}{r}_{aff_n}$	Nitrate affinity of picophytoplankton	$m^3 * mg^{-1} * d^{-1}$	6.E-3
quP3n4X	$\overset{pico}{r}_{aff_a}$	Ammonium affinity of picophytoplankton	$m^3 * mg^{-1} * d^{-1}$	7.E-3

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Table 13 – continued from previous page

Code ID	Symbol	Description	Unit	Value
quP4n3X	$r^{micro}_{aff_n}$	Nitrate affinity of microphytoplankton	$m^3 * mg^{-1} * d^{-1}$	2.E-3
quP4n4X	$r^{micro}_{aff_a}$	Ammonium affinity of microphytoplankton	$m^3 * mg^{-1} * d^{-1}$	2.E-3
qurP1fX	$r^{dia}_{aff_{\mathbb{F}}}$	Iron affinity of diatoms	$m^3 * mg^{-1} * d^{-1}$	3.E-4
qurP1pX	$r^{dia}_{aff_{\mathbb{P}}}$	Phosphate affinity of diatoms	$m^3 * mg^{-1} * d^{-1}$	3.E-3
qurP2fX	$r^{nano}_{aff_{\mathbb{F}}}$	Iron affinity of nanophytoplankton	$m^3 * mg^{-1} * d^{-1}$	4.E-4
qurP2pX	$r^{nano}_{aff_{\mathbb{P}}}$	Phosphate affinity of nanophytoplankton	$m^3 * mg^{-1} * d^{-1}$	4.E-3
qurP3fX	$r^{pico}_{aff_{\mathbb{F}}}$	Iron affinity of picophytoplankton	$m^3 * mg^{-1} * d^{-1}$	6.E-4
qurP3pX	$r^{pico}_{aff_{\mathbb{P}}}$	Phosphate affinity of picophytoplankton	$m^3 * mg^{-1} * d^{-1}$	6.E-3
qurP4fX	$r^{micro}_{aff_{\mathbb{F}}}$	Iron affinity of microphytoplankton	$m^3 * mg^{-1} * d^{-1}$	2.E-4
qurP4pX	$r^{micro}_{aff_{\mathbb{P}}}$	Phosphate affinity of microphytoplankton	$m^3 * mg^{-1} * d^{-1}$	2.E-3
resP1mX	w^{dia}_{lim}	Maximal subsiding velocity of diatoms	$m * d^{-1}$	5.
resP2mX	w^{nano}_{lim}	Maximal subsiding velocity of nanophytoplankton	$m * d^{-1}$	0.E0
resP3mX	w^{pico}_{lim}	Maximal subsiding velocity of picophytoplankton	$m * d^{-1}$	0.E0
resP4mX	w^{micro}_{lim}	Maximal subsiding velocity of microphytoplankton	$m * d^{-1}$	5.
sdoP1X	r^{dia}_{mort}	1.1 of minimal specific mortality rate of diatoms	d^{-1}	5.E-2
sdoP2X	r^{nano}_{mort}	1.1 of minimal specific mortality rate of nanophytoplankton	d^{-1}	5.E-2
sdoP3X	r^{pico}_{mort}	1.1 of minimal specific mortality rate of picophytoplankton	d^{-1}	5.5E-2
sdoP4X	r^{micro}_{mort}	1.1 of minimal specific mortality rate of microphytoplankton	d^{-1}	4.5E-2
srsP1X	r^{dia}_{resp}	Specific rest respiration of diatoms at reference temperature	d^{-1}	4.E-2

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Table 13 – continued from previous page

Code ID	Symbol	Description	Unit	Value
srsP2X	r^{nano}_{resp}	Specific rest respiration of nanophytoplankton at reference temperature	d^{-1}	4.E-2
srsP3X	r^{pico}_{resp}	Specific rest respiration of picophytoplankton at reference temperature	d^{-1}	4.5E-2
srsP4X	r^{micro}_{resp}	Specific rest respiration of microphytoplankton at reference temperature	d^{-1}	3.5E-2
sumP1X	g^{dia}_{max}	Specific maximal productivity of diatoms at reference temperature	d^{-1}	1.375
sumP2X	g^{nano}_{max}	Specific maximal productivity of nanophytoplankton at reference temperature	d^{-1}	1.625
sumP3X	g^{pico}_{max}	Specific maximal productivity of picophytoplankton at reference temperature	d^{-1}	2.
sumP4X	g^{micro}_{max}	Specific maximal productivity of microphytoplankton at reference temperature	d^{-1}	1.125
xqcP1nX	$\frac{q^{dia}_{ref_{\mathbb{N}:\mathbb{C}}}}{\texttt{qnRPIcX}}$	Factor of qpRPIcX giving the treshold for phosphorus limitation of diatoms	1	1.
xqcP1pX	$\frac{q^{dia}_{ref_{\mathbb{P}:\mathbb{C}}}}{\texttt{qpRPIcX}}$	Factor of qpRPIcX giving the treshold for nitrogen limitation of diatoms	1	1.
xqcP2nX	$\frac{q^{nano}_{ref_{\mathbb{N}:\mathbb{C}}}}{\texttt{qnRPIcX}}$	Factor of qnRPIcX giving the treshold for phosphorus limitation of nanophytoplankton	1	1.
xqcP2pX	$\frac{q^{nano}_{ref_{\mathbb{P}:\mathbb{C}}}}{\texttt{qpRPIcX}}$	Factor of qpRPIcX giving the treshold for nitrogen limitation of nanophytoplankton	1	1.
xqcP3nX	$\frac{q^{pico}_{ref_{\mathbb{N}:\mathbb{C}}}}{\texttt{qnRPIcX}}$	Factor of qnRPIcX giving the treshold for phosphorus limitation of picophytoplankton	1	1.

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Table 13 – continued from previous page

Code ID	Symbol	Description	Unit	Value
xqcP3pX	$\frac{{}^{pico}q_{ref\,\mathbb{P}:\mathbb{C}}}{\texttt{qpRPIcX}}$	Factor of qpRPIcX giving the treshold for nitrogen limitation of picophytoplankton	1	1.
xqcP4nX	$\frac{{}^{micro}q_{ref\,\mathbb{N}:\mathbb{C}}}{\texttt{qnRPIcX}}$	Factor of qnRPIcX giving the treshold for phosphorus limitation of microphytoplankton	1	1.
xqcP4pX	$\frac{{}^{micro}q_{ref\,\mathbb{P}:\mathbb{C}}}{\texttt{qpRPIcX}}$	Factor of qpRPIcX giving the treshold for nitrogen limitation of microphytoplankton	1	1.
xqnP1X	$\frac{{}^{dia}q_{max\,\mathbb{N}:\mathbb{C}}}{\texttt{qnRPIcX}}$	Factor of qnRPIcX giving the maximal nitrogen to carbon ratio for diatoms	1	1.075
xqnP2X	$\frac{{}^{nano}q_{max\,\mathbb{N}:\mathbb{C}}}{\texttt{qnRPIcX}}$	Factor of qnRPIcX giving the maximal nitrogen to carbon ratio for nanophytoplankton	1	1.075
xqnP3X	$\frac{{}^{pico}q_{max\,\mathbb{N}:\mathbb{C}}}{\texttt{qnRPIcX}}$	Factor of qnRPIcX giving the maximal nitrogen to carbon ratio for picophytoplankton	1	1.05
xqnP4X	$\frac{{}^{micro}q_{max\,\mathbb{N}:\mathbb{C}}}{\texttt{qnRPIcX}}$	Factor of qnRPIcX giving the maximal nitrogen to carbon ratio for microphytoplankton	1	1.1
xqpP1X	$\frac{{}^{dia}q_{max\,\mathbb{P}:\mathbb{C}}}{\texttt{qpRPIcX}}$	Factor of qpRPIcX giving the maximal phosporus to carbon ratio for diatoms	1	2.
xqpP2X	$\frac{{}^{nano}q_{max\,\mathbb{P}:\mathbb{C}}}{\texttt{qpRPIcX}}$	Factor of qpRPIcX giving the maximal phosporus to carbon ratio for nanophytoplankton	1	2.
xqpP3X	$\frac{{}^{pico}q_{max\,\mathbb{P}:\mathbb{C}}}{\texttt{qpRPIcX}}$	Factor of qpRPIcX giving the maximal phosporus to carbon ratio for picophytoplankton	1	1.5
xqpP4X	$\frac{{}^{micro}q_{max\,\mathbb{P}:\mathbb{C}}}{\texttt{qpRPIcX}}$	Factor of qpRPIcX giving the maximal phosporus to carbon ratio for microphytoplankton	1	2.7

1.14 sedimentation.nml: sedimentation_parameters

Code ID	Symbol	Description	Unit	Value
rP1mX	w_0^{dia}	sinking velocity of diatoms	$m * d^{-1}$	0.00E+00
rP2mX	w_0^{nano}	sinking velocity of nanophytoplankton	$m * d^{-1}$	0.00E+00
rP3mX	w_0^{pico}	sinking velocity of picophytoplankton	$m * d^{-1}$	0.00E+00
rP4mX	w_0^{micro}	sinking velocity of microphytoplankton	$m * d^{-1}$	0.00E+00
rR4mX	w_0^{small}	sinking velocity of small POM	$m * d^{-1}$	1.
rR6mX	w_0^{med}	sinking velocity of medium size POM	$m * d^{-1}$	5.
rR8mX	w_0^{large}	sinking velocity of large POM	$m * d^{-1}$	10.

2 Complementary empirical relationships

Some empirical relations that complement the information in the article are given here. These comprise:

- the chemical equilibrium ccoefficients used in the sub-model for the carbonate system,
- the different options of alkalinity regressions from temperature and salinity from literature that are available in the model,
- saturation state equilibrium coefficients,
- resuspension cocoefficients.

2.1 Carbonate system equilibrium states

The solution of the carbonate system equations requires the chemical equilibrium coefficients, which are approximated from the regressions given below using ocean temperature, salinity and pressure.

The regression for constant k_0 used to compute p_{CO_2} taken from *Weiss, 1974* is given by:

$$\log_e k_0 = \frac{93.4517}{\frac{T[K]}{100}} - 60.2409 + 23.3585 * \log_e \frac{T[K]}{100} + S[psu] * \left(0.023517 - 0.023656 * \frac{T[K]}{100} + 0.0047036 * \left(\frac{T[K]}{100}\right)^2\right) .$$

The constants k_1, k_2 used to compute $c_{[CO_2^*]}$, $c_{HCO_3^-}$ are at reference conditions given by the formulation of *Millero, 1995* using the *Mehrbach et al., 1973* data on seawater scale:

$$-\log_{10}\tilde{k}_1 = \frac{3670.7}{T[\mathrm{K}]} - 62.008 + 9.7944 * \log_e T[\mathrm{K}] - 0.0118 * S[\mathrm{psu}] + 0.000116 * S[\mathrm{psu}]^2$$

$$-\log_{10}\tilde{k}_2 = \frac{1394.7}{T[\mathrm{K}]} + 4.777 - 0.0184 * S[\mathrm{psu}] + 0.000118 * S[\mathrm{psu}]^2 \ .$$

This formulation is amended considering the dependency on sea-water pressure following *Millero, 1995*. For k_1 the pressure dependency is derived from changes of volume and compressibiliy and given by

$$\Delta_v = -25.5 + 0.1271 * T[^\circ\mathrm{C}]$$
$$\Delta_k = \frac{(-3.08 + 0.0877 * T[^\circ\mathrm{C}]}{1000}$$
$$\log_e \frac{k_1}{\tilde{k}_1} = \left(-\Delta_v + \frac{\Delta_k}{2}\mathrm{p[bar]}\right)\frac{\mathrm{p[bar]}}{R_{gas}T[\mathrm{K}]} \ ,$$

while for k_2 it reads

$$\Delta_v = -15.82 - 0.0219 * T[^\circ\mathrm{C}]$$
$$\Delta_k = \frac{1.13 - 0.1475 * T[^\circ\mathrm{C}]}{1000}$$
$$\log_e \frac{k_2}{\tilde{k}_2} = (-\Delta_v + \frac{\Delta_k}{2}\mathrm{p[bar]})\frac{\mathrm{p[bar]}}{R_{gas}T[\mathrm{K}]} \ .$$

The constant k_b to detemetmine $c_{\mathrm{B(OH)_3}}$ is taken from *Millero, 1995* using data from *Dickson, 1990*. At reference conditions it is given by

$$\log_e\tilde{k}_b =$$
$$\frac{(-8966.9 - 2890.53 * \sqrt{S[\mathrm{psu}]} - 77.942 * S[\mathrm{psu}] + 1.728 * S[\mathrm{psu}]^{\frac{3}{2}} - 0.0996 * S[\mathrm{psu}]^2)}{T[\mathrm{K}]}$$
$$+ 148.0248 + 137.1942 * \sqrt{S[\mathrm{psu}]} + 1.62142 * S[\mathrm{psu}]$$
$$+ (-24.4344 - 25.085 * \sqrt{S[\mathrm{psu}]} - 0.2474 * S[\mathrm{psu}]) * \log_e \frac{T[\mathrm{K}]}{100}$$
$$+ 0.053105 * \sqrt{S[\mathrm{psu}]} * T[\mathrm{K}] \ .$$

Like for the two previous constants, a pressure correction term for deviations from reference conditions is applied following *Millero, 1995*.

$$\Delta_v.48 + 0.1622 * T[^\circ\mathrm{C}] - 0.002608 * T[^\circ\mathrm{C}]^2$$
$$\Delta_k\frac{2.84}{1000}$$
$$\log_e \frac{k_b}{\tilde{k}_b} = \left(-\Delta_v\frac{\Delta_k}{2}\mathrm{p[bar]}\right)\frac{\mathrm{p[bar]}}{R_{gas}T[\mathrm{K}]} \ ,$$

2.2 Total alkalinity

Four different regressions from temperature and salinity to determine total alkalinity are available in the model. The choice which regression is used in the simulation is given by the `ISWtalk` parameter in the file `ersem_pelagic_switches.nml`. Their strenghts and limitations are discussed in *Artioli et al., 2012*, and *Blackford et al., 2010* and their respective original publications.

The first one, activated by setting `ISWtalk`= 1, originates from *Bellerby et al., 2005* for salinity > 34.65

$$\mathbb{A}_{tot} = (66.96 * S[\text{psu}] - 36.803) * 10^{-6}$$

and uses the formulation of [Borges1999] for smaller salinities

$$\mathbb{A}_{tot} = (3887. - 46.25 * S[\text{psu}]) * 10^{-6} \ .$$

This description was developed mainly for the North Sea and is provided for legacy configurations.

For `ISWtalk`= 2 the following regression of [Millero1998] is used:

$$\mathbb{A}_{tot} = (520.1 + 51.24 * S[\text{psu}]) * 10^{-6} \ .$$

This is the recommended formulation for the North Atlantic and adjacent shelf seas.

The third option (`ISWtalk`= 3) taken from [Millero1998] includes temperature dependency for waters warmer than 20°C

$$\mathbb{A}_{tot} = \left(S[\text{psu}]/35. * \left(2291. - 2.69 * (T[^\circ\text{C}] - 20) - 0.046 * (T[^\circ\text{C}] - 20)^2\right)\right) * 10^{-6} \ .$$

and uses the regression for salinity dependence identical to the option `ISWtalk`= 2 for lower temperatures.

As a fourth, alternative option (`ISWtalk`= 3) a combination of regressions from [Lee2006] is available , using one formulation for Atlantic waters colder than 20°C

$$\begin{aligned}\mathbb{A}_{tot} = \big(&2305. + 53.97 * (S[\text{psu}] - 35) + 2.74 * (S[\text{psu}] - 35)^2 \\ &-1.16 * (T[^\circ\text{C}] - 20) - 0.04 * (T[^\circ\text{C}] - 20.)^2\big) * 10^{-6}\end{aligned}$$

and one for subtropical, warmer waters:

$$\begin{aligned}\mathbb{A}_{tot} = \big(&2305. + 58.66 * (S[\text{psu}] - 35) + 2.32(S[\text{psu}] - 35)^2 \\ &-1.41(T[^\circ\text{C}] - 20) - 0.04 * (T[^\circ\text{C}] - 20.)^2\big) * 10^{-6} \ .\end{aligned}$$

2.3 Saturation states

The saturation state constans of aragonite and calcite at reference conditions are computed following *Zeebe, 2001* as

$$
\begin{aligned}
\log_{10} \tilde{k}_{arag} = & -171.945 - 0.077993 * T[\mathrm{K}] + \frac{2903.293}{T[\mathrm{K}]} + 71.595 * \log_{10} T[\mathrm{K}] \\
& + \left(-0.068393 + 0.0017276 * T[\mathrm{K}] + \frac{88.135}{T[\mathrm{K}]}\right) * \sqrt{S[\mathrm{psu}]} \\
& - 0.10018 * S[\mathrm{psu}] + 0.0059415 * S[\mathrm{psu}]^{\frac{3}{2}} \\
\log_{10} \tilde{k}_{calc} = & -171.9065 - 0.077993 * T[\mathrm{K}] + \frac{2839.319}{T[\mathrm{K}]} + 71.595 * \log_{10} T[\mathrm{K}] \\
& + \left(-0.77712 + 0.0028426 * T[\mathrm{K}] + \frac{178.34}{T[\mathrm{K}]}\right) * \sqrt{S[\mathrm{psu}]} \\
& - 0.07711 * S[\mathrm{psu}] + 0.0041249 * S[\mathrm{psu}]^{\frac{3}{2}}
\end{aligned}
$$

Also these relationships are corrected for pressure dependency, which for aragonite is given by

$$
\begin{aligned}
\Delta_v &= -46 + 0.5304 * T[^\circ\mathrm{C}] \\
\Delta_k &= -11.76 * 10^{-3} + 0.3692 * 10^{-3} * T[^\circ\mathrm{C}] \\
\log_e \frac{k_2}{\tilde{k}_2} &= \left(-\Delta_v + \frac{\Delta_k}{2}\mathrm{p[bar]}\right)\frac{\mathrm{p[bar]}}{R_{gas} T[\mathrm{K}]} ,
\end{aligned}
$$

while for calcite it is given by

$$
\begin{aligned}
\Delta_v &= -48.76 + 0.5304 * T[^\circ\mathrm{C}] \\
\Delta_k &= -11.76 * 10^{-3} + 0.3692 * 10^{-3} * T[^\circ\mathrm{C}] \\
\log_e \frac{k_2}{\tilde{k}_2} &= \left(-\Delta_v + \frac{\Delta_k}{2}\mathrm{p[bar]}\right)\frac{\mathrm{p[bar]}}{R_{gas} T[\mathrm{K}]} ,
\end{aligned}
$$

The oxygen saturation concentration can be computed using two different empirical relationships. The first, activated by `ISWO2X`= 1 is inherited from older versions of the model:

$$
s_{\mathbb{O}}[\mathrm{ml\,l^{-1}}] = 31.25 * \frac{475. - 2.65 * S[\mathrm{psu}]}{33.5 + T[^\circ\mathrm{C}]} .
$$

For the second option `ISWO2X`= 2 it is taken from *Weiss, 1974*:

$$
\begin{aligned}
\log_e s_{\mathbb{O}}[\mathrm{ml\,l^{-1}}] = & -173.4292 + \frac{249.6339}{\frac{T[\mathrm{K}]}{100}} + 143.3483 * \log_e \frac{T[\mathrm{K}]}{100} - 21.8492 * \frac{T[\mathrm{K}]}{100} \\
& + S[\mathrm{psu}] * \left(-0.033096 + 0.014259 * \frac{T[\mathrm{K}]}{100} + -0.0017 * \left(\frac{T[\mathrm{K}]}{100}\right)^2\right) .
\end{aligned}
$$

This needs to be converted to the model units:

$$
s_{\mathbb{O}}[\mathrm{mmol\,m^{-3}}] = s_{\mathbb{O}}[\mathrm{ml\,l^{-1}}] * \frac{\mathrm{p[Pa]}}{R_{gas} * 298.15}
$$

2.4 Air-sea flux

The gas transfer coefficients regulating the gas flux between sea and atmosphere are taken from *Weiss, 1970* and *Nightingale et al., 2000*

In the case of oxygen two distinct relations are used in relation to the wind speed at sea surface. For wind speeds exceeding 11 m d^{-1} the coefficient is given by

$$k_{air\mathbb{O}}[\mathrm{m\,d^{-1}}] = \frac{24}{100}\left(0.02383 * \boldsymbol{v}^3_{wind}\right) * \frac{\sqrt{1953.4 - 128 * T[^\circ C] + 3.9918 * T[^\circ C]^2 - 0.050091 * T[^\circ C] * *3}}{660}$$

and for lower winds by

$$k_{air\mathbb{O}}[\mathrm{m\,d^{-1}}] = \frac{24}{100}\left(0.31 * \boldsymbol{v}^3_{wind}\right) * \frac{\sqrt{1953.4 - 128 * T[^\circ C] + 3.9918 * T[^\circ C]^2 - 0.050091 * T[^\circ C] * *3}}{660}.$$

For carbon dioxide it is given by

$$k_{air\mathbb{C}}[\mathrm{m\,d^{-1}}] = \frac{24}{100}k_0\left(0.222 * v_{wind}[\mathrm{m\,d^{-1}}]^2 + 0.333 * v_{wind}[\mathrm{m\,d^{-1}}]\right) * \sqrt{\frac{2073.1 - 125.62 * T[^\circ C] + 3.6276 * T[^\circ C]^2. - 0.043219 * T[^\circ C]^3}{600}}.$$

2.5 Resuspension

The erosion parameter $r_{er}[\mathrm{mg\,m^{-2}\,d^{-1}}]$ in the resuspension formulation of the model is computed as

$$r_{er}[\mathrm{mg\,m^{-2}\,d^{-1}}] = 100 * \tau_{crit}[\mathrm{Pa}] * 1000 * 86400$$

where τ_{crit} = 0.0004Pa is the critical stress at sea-bed. The parameter regulating the organic proportion of the resuspended material $\overset{sed}{p_Q}[\mathrm{mg\,m^{-3}}]$ is determined from an empirical relationship with the water depth z:

$$\overset{sed}{p_Q}[\mathrm{mg\,m^{-3}}] = 10 * (-1069 * \log_e(z[\mathrm{m}]/1\mathrm{m}) + 10900)$$

3 References

Artioli, Y., Blackford, J.C., Butenschön, M., Holt, J.T., Wakelin, S.L., Thomas, H., Borges, A.V., Allen, J.I., 2012. The carbonate system in the North Sea: Sensitivity and model validation. Journal of Marine Systems 102-104, 1 – 13. doi:10.1016/j.jmarsys.2012.04.006

Blackford, J., Artioli, Y., Kelly-Gerreyn, B., Martin, A., Tyrrell, T., Somavilla, R., 2010. Sub-model acidification-sensitive calcification rate, including user guide (Project Report No. D2.2). EC FP7 MEECE - 212085.

Borges, A.V., Frankignoulle, M., 1999. Daily and seasonal variations of the partial pressure of CO2 in surface seawater along Belgian and southern Dutch coastal areas. Journal of Marine Systems 19, 251–266. doi:10.1016/S0924-7963(98)00093-1

Bellerby, R.G.J., Olsen, A., Furevik, T., Anderson, L.G., 2005. Response of the Surface Ocean CO2 System in the Nordic Seas and Northern North Atlantic to Climate Change, in: Helgeange, Dokken, T., Furevik, T., Gerdes, R., Berger, W. (Eds.), The Nordic Seas: An Integrated Perspective. American Geophysical Union, pp. 189–197.

Dickson, A.G., 1990. Thermodynamics of the dissociation of boric acid in synthetic seawater from 273.15 to 318.15 K. Deep Sea Research Part A. Oceanographic Research Papers 37, 755–766. doi:10.1016/0198-0149(90)90004-F

Lee, K., Tong, L.T., Millero, F.J., Sabine, C.L., Dickson, A.G., Goyet, C., Park, G.-H., Wanninkhof, R., Feely, R.A., Key, R.M., 2006. Global relationships of total alkalinity with salinity and temperature in surface waters of the world's oceans. Geophys. Res. Lett. 33, L19605. doi:10.1029/2006GL027207

Mehrbach, C., Culberson, C.H., Hawley, J.E., Pytkowicx, R.M., 1973. Measurement of the Apparent Dissociation Constants of Carbonic Acid in Seawater at Atmospheric Pressure1. Limnol. Oceanogr. 18, 897–907. doi:10.4319/lo.1973.18.6.0897

Millero, F.J., 1995. Thermodynamics of the carbon dioxide system in the oceans. Geochimica et Cosmochimica Acta 59, 661–677. doi:10.1016/0016-7037(94)00354-O

Millero, F.J., Lee, K., Roche, M., 1998. Distribution of alkalinity in the surface waters of the major oceans. Marine Chemistry 60, 111–130. doi:10.1016/S0304-4203(97)00084-4

Nightingale, P.D., Malin, G., Law, C.S., Watson, A.J., Liss, P.S., Liddicoat, M.I., Boutin, J., Upstill-Goddard, R.C., 2000. In situ evaluation of air-sea gas exchange parameterizations using novel conservative and volatile tracers. Global Biogeochemical Cycles 14, 373–387. doi:10.1029/1999GB900091

Weiss, R.F., 1970. The solubility of nitrogen, oxygen and argon in water and seawater. Deep Sea Research and Oceanographic Abstracts 17, 721–735. doi:10.1016/0011-7471(70)90037-9

Weiss, R.F., 1974. Carbon dioxide in water and seawater: the solubility of a non-ideal gas. Marine Chemistry 2, 203–215. doi:10.1016/0304-4203(74)90015-2

Zeebe, R.W., Wolf-Gladrow, D., 2001. CO2 in Seawater: Equilibrium, Kinetics, Isotopes, Elsevier Oceanography Series. Elsevier.