

SUPPLEMENTARY INFORMATION

Appendix 1. Parameters and state variables used in the ecological sub-model. Further details can be found online [<http://www.ifremer.fr/docmars/html/parametrage.bio.html>]

Parameter	Definition	Units	Value	Parameter	Definition	Units	Value
<i>General parameters</i>				<i>Freshwater green algae (Chlorophyceae)</i>			
Γ_{SiN}	Si/N ratio	molSi·molN ⁻¹	0.75	μ_{maxgra}	Max. growth rate at 0°C	d ⁻¹	1.0
Γ_{PN}	P/N ratio	molP·molN ⁻¹	0.062	IK_{optgra}	Smith optimal light flux	W·m ⁻²	40
$\Gamma_{CNphyto}$	C/N ratio in phytoplankton	molC·molN ⁻¹	6.625	K_{NO3gra}	Half satur. constant for NO ₃ ⁻	μmol·dm ⁻³	1.00
Γ_{CNzoo}	C/N ratio in zooplankton	molC·molN ⁻¹	5.45	K_{NH4gra}	Half satur. constant for NH ₄ ⁺	μmol·dm ⁻³	1.00
Γ_{ChlN}	Chlorophyll <i>a</i> /N ratio	g chl·molN ⁻¹	1.59	K_{PO4gra}	Half satur. constant for PO ₄ ³⁻	μmol·dm ⁻³	2.00
$\Gamma_{ChlNmax}$	Maximum chlorophyll <i>a</i> /N ratio	g chl·molN ⁻¹	2.5	m_{gra}	Mortality rate at 0°C	d ⁻¹	0.36
$\Gamma_{ChlNextinct}$	Extinction value (giving 70% of the maximum chl <i>a</i> /N ratio)	m ⁻¹	1.0	<i>Pico and Nanophytoplankton</i>			
f_T	Temperature effect on processes	°C ⁻¹	0.07	$\mu_{maxnano}$	Max. growth rate at 0°C	d ⁻¹	0.8
Sal_{thres}	Salinity threshold between freshwater and marine biology	psu	5	$IK_{optnano}$	Smith optimal light flux	W·m ⁻²	70
<i>Diatoms</i>				$K_{NO3nano}$	Half satur. constant for NO ₃ ⁻	μmol·dm ⁻³	0.10
$\mu_{maxdiat}$	Max. growth rate at 0°C	d ⁻¹	0.6	$K_{NH4nano}$	Half satur. constant for NH ₄ ⁺	μmol·dm ⁻³	0.05
$IK_{optdiat}$	Smith optimal light flux	W·m ⁻²	60	$K_{PO4nano}$	Half satur. constant for PO ₄ ³⁻	μmol·dm ⁻³	0.05
$K_{NO3diat}$	Half satur. constant for NO ₃ ⁻	μmol·dm ⁻³	2.00	m_{nano}	Mortality rate at 0°C	d ⁻¹	0.15
$K_{NH4diat}$	Half satur. constant for NH ₄ ⁺	μmol·dm ⁻³	1.50	<i>Dinoflagellates</i>			
$K_{PO4diat}$	Half satur. constant for PO ₄ ³⁻	μmol·dm ⁻³	0.15	$\mu_{maxdino}$	Max. growth rate at 0°C	d ⁻¹	0.4
K_{Sidiat}	Half satur. constant for SiO ₂	μmol·dm ⁻³	1.00	$IK_{optdino}$	Smith optimal light flux	W·m ⁻²	70
m_{diat}	Mortality rate at 0°C	d ⁻¹	0.015	$K_{NO3dino}$	Half satur. constant for NO ₃ ⁻	μmol·dm ⁻³	3.00
<i>Freshwater diatoms</i>				$K_{NH4dino}$	Half satur. constant for NH ₄ ⁺	μmol·dm ⁻³	0.90
$\mu_{maxdiatfresh}$	Max. growth rate at 0°C	d ⁻¹	0.8	$K_{PO4dino}$	Half satur. constant for PO ₄ ³⁻	μmol·dm ⁻³	0.10
$IK_{optdiatfresh}$	Smith optimal light flux	W·m ⁻²	40	m_{dino}	Mortality rate at 0°C	d ⁻¹	0.02
$K_{NO3diatfresh}$	Half satur. constant for NO ₃ ⁻	μmol·dm ⁻³	1.00	<i>Microzooplankton</i>			
$K_{NH4diatfresh}$	Half satur. constant for NH ₄ ⁺	μmol·dm ⁻³	1.00	$\mu_{maxmiczoo}$	Max. growth rate at 0°C	d ⁻¹	0.4
$K_{PO4diatfresh}$	Half satur. constant for PO ₄ ³⁻	μmol·dm ⁻³	0.50	K_{miczoo}	Half satur. constant	μmolN·dm ⁻³	1.0
$K_{Sidiatfresh}$	Half satur. constant for SiO ₂	μmol·dm ⁻³	7.00	Assim _{miczoo}	Assimilation efficiency	-	0.60
$m_{diatfresh}$	Mortality rate at 0°C	d ⁻¹	0.18	Pr _{thresmiczoo}	Nanophyto. predation threshold	μmolN·dm ⁻³	0.10
				excr _{miczoo}	Excretion at 0°C	d ⁻¹	0.10
				m_{miczoo}	Mortality rate at 0°C	d ⁻¹	0.02

Parameter	Definition	Units	Value
<i>Freshwater microzooplankton</i>			
$\mu_{\text{maxmiczoofresh}}$	Max. growth rate at 0°C	d ⁻¹	1.60
$K_{\text{miczoofresh}}$	Half saturation constant	$\mu\text{molN}\cdot\text{dm}^{-3}$	4.0
$\text{Assim}_{\text{miczoofresh}}$	Assimilation efficiency	-	0.45
$\text{Pr}_{\text{thresmiczoofresh}}$	Nanophyto. predation threshold	$\mu\text{molN}\cdot\text{dm}^{-3}$	0.10
$\text{excr}_{\text{miczoofresh}}$	Excretion at 0°C	d ⁻¹	0.72
$m_{\text{miczoofresh}}$	Mortality rate at 0°C	d ⁻¹	0.02
<i>Mesozooplankton</i>			
$\mu_{\text{maxmeszoo}}$	Max. growth rate at 0°C	d ⁻¹	0.25
γ_{meszoo}	Slope of Ivlev function	$\text{dm}^3\cdot\mu\text{molN}^{-1}$	0.30
$\text{Assim}_{\text{meszoo}}$	Assimilation efficiency	-	0.60
$\text{Pr}_{\text{thresmeszoo}}$	Predation threshold	$\mu\text{molN}\cdot\text{dm}^{-3}$	2.0
$\text{excr}_{\text{meszoo}}$	Excretion at 0°C	d ⁻¹	0.03
$m_{1\text{meszoo}}$	Min. mortality rate at 0°C	d ⁻¹	0.05
$m_{2\text{meszoo}}$	Biomass-dependent mortality rate at 0°C	$\text{dm}^3\cdot\text{d}^{-1}\cdot\mu\text{molN}^{-1}$	0.04
r_{CDW}	C content in dry weight	$\text{gC}\cdot\text{g dry weight}^{-1}$	0.25
<i>Organic matter</i>			
k_{Nminer}	N mineralization rate at 0°C	d ⁻¹	0.02
k_{Pminer}	P mineralization rate at 0°C	d ⁻¹	0.15
k_{Sidiss}	Si dissolution rate at 0°C	d ⁻¹	0.07
$k_{\text{Nminerbent}}$	Benthic N mineraliz. rate at 0°C	d ⁻¹	0.002
$k_{\text{Pminerbent}}$	Benthic P mineraliz. rate at 0°C	d ⁻¹	0.015
$k_{\text{Sidissbent}}$	Benthic Si dissolut. rate at 0°C	d ⁻¹	0.005
$k_{\text{minerbent}}$	Mineralization ratio in the benthos	-	0.2
<i>Particulate adsorbed P</i>			
k_{desorp}	P desorption rate	d ⁻¹	2.4
k_{adsorp}	P adsorption rate	$\text{dm}^3\cdot\mu\text{molP}^{-1}\cdot\text{d}^{-1}$	0.12
$Q_{\text{adsorpmax}}$	Maximum P adsorption capacity in suspended matter	$\mu\text{molP}\cdot\text{g}^{-1}$	40
$Q_{\text{adsorpmaxSed}}$	Maximum P adsorption capacity in the sediment	$\mu\text{molP}\cdot\text{g}^{-1}$	7

Parameter	Definition	Units	Value
<i>Oxygen</i>			
r_{ps}	Photosynthetic ratio	-	1.20
r_{O2N}	Photosynthetic O ₂ /N ratio	$\text{mg}\cdot\mu\text{mol}^{-1}$	0.212
r_{O2nitrif}	Nitrification O ₂ /N ratio	$\text{mg}\cdot\mu\text{mol}^{-1}$	0.064
K_{O2miner}	Half saturation constant for O ₂ mineralization	$\text{mgO}_2\cdot\text{dm}^{-3}$	1.20
$k_{\text{nitrifsea}}$	Nitrification rate in seawater at 0°C	d ⁻¹	0.04
$k_{\text{nitrifresh}}$	Nitrification rate in freshwater at 0°C	d ⁻¹	0.20
$k_{\text{nitrifsed}}$	Nitrification rate in sediment at 0°C	d ⁻¹	0.02
$\theta_{\text{respphyto}}$	Phytoplankton respiration rate	$\text{mgO}_2\cdot\text{d}^{-1}\cdot\mu\text{molN}^{-1}$	0.030
θ_{respzoo}	Zooplankton respiration rate	$\text{mgO}_2\cdot\text{d}^{-1}\cdot\mu\text{molN}^{-1}$	0.050
<i>Grazing rates</i>			
$\text{Mesz}_{\text{capt}}\text{diat}$	Grazing on diatoms by mesozooplankton	-	1.0
$\text{Mesz}_{\text{capt}}\text{dino}$	Grazing on dinoflagellates by mesozooplankton	-	0.1
$\text{Mesz}_{\text{capt}}\text{micz}$	Grazing on microzooplankton by mesozooplankton	-	0.7
$\text{Micz}_{\text{capt}}\text{diat}$	Grazing on diatoms by microzooplankton	-	0.0
$\text{Micz}_{\text{capt}}\text{nano}$	Grazing on nanoflagellates by microzooplankton	-	1.0
$\text{Micz}_{\text{capt}}\text{det}$	Grazing on detrital organic matter by microzooplankton	-	0.8
$\text{Miczfresh}_{\text{capt}}\text{diat}$	Grazing on diatoms by freshwater microzooplankton	-	1.0
$\text{Miczfresh}_{\text{capt}}\text{chlo}$	Grazing on green algae by freshwater microzooplankton	-	0.3
$\text{Miczfresh}_{\text{capt}}\text{det}$	Grazing on detrital organic matter by freshwater microzoo.	-	0.8

Parameter	Definition	Units	Value
<i>Benthos and water–sediment interface, and optical parameters</i>			
$\text{filtbenth}_{\text{max}}$	Maximum benthic filtration rate	$\text{m}^3 \cdot \text{d}^{-1} \cdot \text{m}^{-2}$	1.0
$\text{m}_{\text{diatsed}}$	Mortality rate of benthic diatoms at 0°C	d^{-1}	0.03
flx_{eros}	Erosion flux	$\text{kg} \cdot \text{m}^{-2} \cdot \text{s}^{-1}$	$1 \cdot 10^{-5}$
$\text{vfall}_{\text{detzoo}}$	Deposition rate for detritus from zooplankton	$\text{m} \cdot \text{s}^{-1}$	0.0014
$\text{vfall}_{\text{detphy}}$	Deposition rate for detritus from phytoplankton	$\text{m} \cdot \text{s}^{-1}$	$5 \cdot 10^{-5}$
$\text{extinc}_{\text{wat}}$	General extinction coefficient	m^{-1}	0.06
$\text{extinc}_{\text{spm}}$	Susp. Matt. coeff. in adsorption	$\text{l} \cdot \text{mg}^{-1} \cdot \text{m}^{-1}$	0.05
$\text{extinc}_{\text{chl1}}$	Chl coeff. in adsorption	$\text{l} \cdot \text{mg}^{-1} \cdot \text{m}^{-1}$	0.05
$\text{extinc}_{\text{chl2}}$	Chl exponent in adsorption	$\text{s} \cdot \text{d}$	0.75
Γ_{PARrad}	PAR ratio in solar energy	$\text{s} \cdot \text{d}$	0.43