The following appendices (1 to 5) accompany the article

Modelling diatom and *Phaeocystis* blooms and nutrient cycles in the Southern Bight of the North Sea: the MIRO model

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Appendix 1. MIRO model: the 32 state variables

Variable	Symbol
Biological state variables:	
Diatoms: DA = DAF + DAS + DAR	
Functional and structural metabolites	DAF
Monomers	DAS
Reserves	DAR
Nanoflagellates: NF = NFF + NFS + NFR	
Functional and structural metabolites	NFF
Monomers	NFS
Reserve products	NFR
Phaeocystis colonies: OP = OPF + OPS + OPR + OPM	
Functional and structural	OPF
Monomers	OPS
Reserve products	OPR
Mucous matrix	OPM
Bacteria	BC
Microzooplankton	MZ
Copepods	CP
Organic matter:	
Monomeric: carbon, nitrogen	BSC, BSN
Dissolved polymers (high biodegradability): carbon (C), nitrogen (N), phosphorus (P)	DC_1, DN_1, DP_1
Dissolved polymers (low biodegradability): C, N, P	DC_2, DN_2, DP_2
Particulate organic matter (high biodegradability): C, N, P	PC_1, PN_1, PP_1
Particulate organic matter (low biodegradability): C, N, P	PC_2, PN_2, PP_2
Detrital biogenic silica: Si	BSi
Inorganic nutrients:	
Nitrate	NO_3
Ammonium	NH_4
Phosphate	PO_4
Silicic acid	DSi

Appendix 2. The MIRO model: processes

Description	Symbol
Phytoplankton:	
Photosynthesis	φ_i; i = DA, NF, OP
Growth	μ_i; i = DA, NF, OP
Reserve/mucus synthesis	s_i; i = DAR, NFR, OPR, OPM
Reserve/mucus catabolism	c_i; i = DAR, NFR, OPR, OPM
Exudation	e_i; i = DAS, NFS, OPS
Respiration	$resp_i$; i = DA, NF, OP
Autolysis	lys_i; i = DA, NF, OP
Colony lysis	*lyscol*
Sedimentation	sed_i; i = DA, OP
Nutrient uptake	upt^k_{PHY}; k = NO_3, NH_4, PO_4, SiO; PHY = DA + NF + OP
Zooplankton:	
Grazing	$g_{l/q}$; l = MZ, CP for l = MZ, q = BC, NF l = CP, q = DA, MZ
Growth	μ_l; l = MZ, CP
Natural mortality	lys_l; l = MZ, CP
Egestion	eg_l; l = MZ, CP
Nutrient regeneration	reg^k_l; l = MZ, CP; k = NH_4, PO_4
Microbial loop:	
C and nutrient uptake	upt^k_{BC}; k = BSC, BSN, NH_4, PO_4
Growth	μ_{BC}
Natural mortality	lys_{BC}
Ammonification	reg^{NH4}_{BC}
Nitrification	*ni*
Denitrification	*dni*
Ectoenzymatic hydrolysis of DOM	$elys_{Di}$; Di = $DC_{1,2}$ = $DN_{1,2}$ = $DP_{1,2}$
Hydrolysis of POM	$elys_{Di}$; Pi = $PC_{1,2}$ = $PN_{1,2}$ = $PP_{1,2}$
Dissolution of BSi	lys_{BSi}
Sedimentation of POM	sed_{Pi}; Pi = $PC_{1,2}$ = $PN_{1,2}$ = $PP_{1,2}$
Benthos:	
Nitrification	ni^B
PO_4/NH_4-adsorption/desorption	ads^B_K: k = NH_4, PO_4
Nutrient exchanges at the sediment-water interface	J^k; k = NO_3, NH_4, PO_4, SiO

Appendix 3. The MIRO model: conservation equations

Phytoplankton

Diatoms: DA = DAF + DAS + DAR; *z* = depth

$$\frac{dDAF}{dt} = \mu_{DA} - \left[g_{CP/DA} + lys_{DA} + \frac{1}{z} sed_{DA}\right] \cdot \frac{DAF}{DA}$$

$$\frac{dDAS}{dt} = \varphi_{DA} - e_{DAS} - s_{DAR} + c_{DAR} - \mu_{DA} - resp_{DA} - \left[g_{CP/DA} + lys_{DA} + \frac{1}{z} sed_{DA}\right] \cdot \frac{DAS}{DA}$$

$$\frac{dDAR}{dt} = s_{DAR} - c_{DAR} - \left[g_{CP/DA} + lys_{DA} + \frac{1}{z} sed_{DA}\right] \cdot \frac{DAR}{DA}$$

Nanophytoflagellates: NF = NFF + NFS + NFR

$$\frac{dNFF}{dt} = \mu_{NF} - [g_{MZ/NF} + lys_{NF}] \cdot \frac{NFF}{NF} + [(1 - aggr) \cdot lyscol] \cdot \frac{OPF}{OP}$$

$$\frac{dNFS}{dt} = \varphi_{NF} - e_{NFS} - s_{NFR} + c_{NFR} - \mu_{NF} - resp_{NF} - [g_{MZ/NF} + lys_{NF}] \cdot \frac{NFS}{NF} + [(1 - aggr) \cdot lyscol] \cdot \frac{OPS}{OP}$$

$$\frac{dNFR}{dt} = s_{NFR} - c_{NFR} - [g_{MZ/NF} + lys_{NF}] \cdot \frac{NFR}{NF} + [(1 - aggr) \cdot lyscol] \cdot \frac{OPR}{OP}$$

Phaeocystis colonies: OP = OPF + OPS + OPR + OPM

$$\frac{dOPF}{dt} = \mu_{OP} - \left[lys_{OP} + \frac{1}{z} sed_{OP} + lyscol\right] \cdot \frac{OPF}{OP}$$

$$\frac{dOPS}{dt} = \varphi_{OP} - e_{OPS} - s_{OPR} + c_{OPR} - s_{OPM} + c_{OPM} - \mu_{OP} - resp_{OP} - \left[lys_{OP} + \frac{1}{z} sed_{OP} + lyscol\right] \cdot \frac{OPS}{OP}$$

$$\frac{dOPR}{dt} = s_{OPR} - c_{OPR} - \left[lys_{OP} + \frac{1}{z} sed_{OP} + lyscol\right] \cdot \frac{OPR}{OP}$$

$$\frac{dOPM}{dt} = s_{OPM} - c_{OPM} - \left[lys_{OP} + \frac{1}{z} sed_{OP} + lyscol\right] \cdot \frac{OPM}{OP}$$

Zooplankton

Microzooplankton: MZ

$$\frac{dMZ}{dt} = \mu_{MZ} - lys_{MZ} - g_{CP/MZ}$$

Copepods: CP

$$\frac{dCP}{dt} = \mu_{CP} - lys_{CP}$$

Microbial loop

Bacteria: BC

$$\frac{dBC}{dt} = \mu_{BC} - lys_{BC} - g_{MZ/BC}$$

Organic matter: BSC, BSN, DC_i, DN_i, DP_i, PC_i, PN_i, PP_i ($i = 1, 2$)

Organic carbon

$$\frac{dBSC}{dt} = elys_{DC1} + elys_{DC2} + lys_{DA}\frac{DAS}{DA} + lys_{NF}\frac{NFS}{NF} + lys_{OP}\frac{OPS}{OP} + e_{DA} + e_{NF} + e_{OP} - upt_{BC}^{BSC}$$

$$\frac{dDCi}{dt} = \varepsilon_{di}lys_{BIO} + \gamma_{di}eg_{ZOO} - elys_{DCi} + elys_{PCi} + \tau_{di}[1 - aggr]\cdot lyscol\frac{OPM}{OP}$$

$$\frac{dPCi}{dt} = \varepsilon_{pi}lys_{BIO} + \gamma_{pi}eg_{ZOO} - elys_{PCi} - \frac{1}{z}sed_{PCi} + \tau_{pi}[aggr]\cdot lyscol$$

where

$$lys_{BIO} = lys_{DA}\frac{DAF + DAR}{DA} + lys_{NF}\frac{NFF + NFR}{NF} + lys_{OP}\frac{OPF + OPR}{OP} + lys_{BC} + lys_{MZ}$$

$$eg_{ZOO} = eg_{CP} + eg_{MZ} + lys_{CP}$$

Organic nitrogen

$$\frac{dBSN}{dt} = elys_{DN1} + elys_{DN2} - upt_{BC}^{BSN}$$

$$\frac{dDNi}{dt} = \varepsilon_{di}lysN_{BIO} + \gamma_{di}egN_{ZOO} - elys_{DNi} + elys_{PNi}$$

$$\frac{dPNi}{dt} = \varepsilon_{pi}lysN_{BIO} + \gamma_{pi}egN_{ZOO} + \tau_{pi}[aggr]\cdot lyscol\cdot\frac{OPF}{CN_{PHY}} - elys_{PNi} - \frac{1}{z}sed_{PNi}$$

where

$$lysN_{BIO} = \frac{1}{CN_{PHY}}\cdot\left[lys_{DA}\cdot\frac{DAF}{DA} + lys_{NF}\cdot\frac{NFF}{NF} + lys_{OP}\frac{OPF}{OP}\right] + \frac{lys_{BC}}{CN_{BC}} + \frac{lys_{MZ}}{CN_{ZOO}}$$

$$egN_{ZOO} = fp_{CP}\cdot\left[\frac{1}{CN_{PHY}}\cdot\left[g_{MZ/NF}\cdot\frac{NFF}{NF} + g_{CP/DA}\cdot\frac{DAF}{DA}\right] + \frac{1}{CN_{CP}}\cdot[g_{CP/MZ} + g_{MZ/BC} + lys_{CP}]\right]$$

Organic phosphorus

$$\frac{dDPi}{dt} = \varepsilon_{di}lysP_{BIO} + \gamma_{di}eg_{ZOO} - elys_{DPi} + elys_{PPi}$$

$$\frac{dPPi}{dt} = \varepsilon_{pi}lysP_{BIO} + \gamma_{pi}egP_{ZOO} + \tau_{pi}[aggr]\cdot lyscol\cdot\frac{OPF}{CP_{PHY}} - elys_{PPi} - \frac{1}{z}sed_{PPi}$$

where

$$lysP_{BIO} = \frac{1}{CP_{PHY}}\cdot\left[lys_{DA}\cdot\frac{DAF}{DA} + lys_{NF}\cdot\frac{NFF}{NF} + lys_{OP}\frac{OPF}{OP}\right] + \frac{lys_{BC}}{CP_{BC}} + \frac{lys_{MZ}}{CP_{ZOO}}$$

$$egP_{ZOO} = fp_{CP}\cdot\left[\frac{1}{CP_{PHY}}\cdot\left[g_{MZ/NF}\cdot\frac{NFF}{NF} + g_{CP/DA}\cdot\frac{DAF}{DA}\right] + \frac{1}{CP_{CP}}\cdot[g_{CP/MZ} + g_{MZ/BC} + lys_{CP}]\right]$$

Nutrients

$$\frac{dNO_3}{dt} = -upt_{PHY}^{NO3} + ni - \frac{1}{z}J^{NO3}$$

$$\frac{dNH_4}{dt} = -upt_{PHY}^{NH4} - ni - \frac{1}{z}J^{NH4} + reg_{BC}^{NH4} + reg_{MZ}^{NH4} + reg_{CP}^{NH4}$$

$$\frac{dPO_4}{dt} = -upt_{PHY}^{PO4} - upt_{BC}^{PO4} - \frac{1}{z}J^{PO4} + elys_{DPi} + elys_{PPi} + reg_{MZ}^{PO4} + reg_{CP}^{PO4}$$

$$\frac{dDSi}{dt} = -upt_{DA}^{DSi} + lys_{BSi}$$

$$\frac{dBSi}{dt} = -k_b^{Si}BSi + \frac{1}{CSi}\cdot\left[g_{CP/DA} + \frac{1}{z}sed_{DA}\right]\cdot\frac{DAF}{DA}$$

Appendix 4. The MIRO model: kinetic equations of processes

Phytoplankton

$i = DA, NF, OP$

Photosynthesis

$$\varphi_i = k^i_{\max}\left[1 - e^{\frac{-\alpha^i I}{k^i_{\max}}}\right] \cdot i\,F \quad (1)$$

where $\alpha^i = \dfrac{k^i_{\max}}{I^i_k}$ and I^i_k = light adaptation

$$I = I_0[1 - a_{sea}] \cdot e^{-\eta z}$$

α_{sea}: sea surface albedo

I_0: incident PAR [µmol m^{-2} s^{-1}]; z: depth [m]

$$\eta = \eta_m + \eta_{self}\frac{1}{CChl}[DAF + NFF + OPF]$$

Lysis and exudation

$$lys_i = k^i_{lys} \cdot i \quad (2)$$

where $k^i_{lys} = k^i_{lys\min}[1 + 7.5 \cdot (1 - \tilde{N}_i)]$

$$lyscol = k_{lyscol} \cdot OP \quad (3)$$

$$e_i = \varepsilon \cdot iS \quad (4)$$

Synthesis (s) and catabolism (c) of intracellular reserve products

$$S_i = \frac{iS}{iF} - k_s \quad \text{where} \quad s_i = sr^i_{\max}\frac{S_i^2}{S_i^2 + k_S^2} \cdot iF \quad (5)$$

$$c_i = k^i_{cR} \cdot iR \quad (6)$$

Synthesis (s) and catabolism (c) of *Phaeocystis* mucus

$$s_{OP} = smu_{\max}\frac{S_i^2}{S_i^2 + k_S^2} \cdot OPF \quad (7)$$

$$c_{OP} = k^i_{cR} \cdot [OPM - OPM_{\min}] \quad \text{where} \quad \mu_i = \mu^i_{\max}\frac{S_i^2}{S_i^2 + k_S^2} \cdot \tilde{N}_i \cdot iF \quad (8)$$

Growth and respiration

$$\mu_i = \mu^i_{\max}\frac{S_i^2}{S_i^2 + k_S^2} \cdot \tilde{N}_i \cdot iF$$

where

$$DIN = NO_3 + NH_4 \quad (9)$$

$$\tilde{N}_{DA} = \frac{DIN \cdot PO_4 \cdot DSi}{k_P^{DA} \cdot DIN \cdot DSi + k_N^{DA} \cdot PO_4 \cdot DSi + k_{Si}^{DA} \cdot DIN \cdot PO_4 + DIN \cdot PO_4 \cdot DSi}$$

$$\tilde{N}_{NF,OP} = \frac{DIN \cdot PO_4}{k_N^{NF,OP} \cdot PO_4 + k_P^{NF,OP} \cdot DIN + DIN \cdot PO_4}$$

$$resp_i = k^i_f \cdot iF + \xi\mu_i \quad (10)$$

where $\xi = ecs_{NH4}[1 - f_{NO3}] + ecs_{NO3}f_{NO3}$ (metabolic cost)

Sedimentation (diatoms, biogenic silica)

$$sed_{DA} = k^{DA}_{sed}DA \quad (11)$$

$$sed_{BSi} = k^{DA}_{sed}BSi \quad (12)$$

where $k^{DA}_{sed} = k^{DA}_{sed\min}[1 + 5 \cdot (1 - \tilde{N}_{DA})]$

Nutrient uptake

$$upt^{NO3}_{PHY} = \frac{f_{NO3}}{CN_{PHY}}\sum_i \mu_i \quad (13)$$

where $f_{NO3} = 1 - \dfrac{I_m NH_4}{NH_4 + k_i}$

$$upt^{NH4}_{PHY} = \frac{1 - f_{NO3}}{CN_{PHY}}\sum_i \mu_i \quad (14)$$

$$upt^{Si}_{DA} = \mu_{DA}SiC \quad (15)$$

$$upt^{PO4}_{PHY} = \frac{1}{CP}\sum_i \mu_i \quad (16)$$

Microzooplankton

Grazing

$g_{MZ} = g_{MZ/BC} + g_{MZ/NF}$

where:

$$g_{MZ/BC} = g_{\max}^{MZ/BC} \frac{BC^2}{[k_g^{MZ/BC}]^2 + BC^2} MZ \quad (17)$$

$$g_{MZ/NF} = g_{\max}^{MZ/NF} \frac{NF^2}{[k_g^{MZ/BC}]^2 + NF^2} MZ \quad (18)$$

Growth

$$\mu_{MZ} = y_{MZ/BC} \cdot g_{MZ/BC} + y_{MZ/NF} \cdot g_{MZ/NF} \quad (19)$$

Natural mortality (lysis)

$$lys_{MZ} = k_d^{MZ} \cdot MZ \quad (20)$$

Egestion

$$eg_{MZ} = fp_{MZ} \cdot g_{MZ} \quad (21)$$

Excretion and nutrient regeneration

$$ex_{MZ} = [1 - fp] \cdot g_{MZ} - \mu_{MZ} \quad (22)$$

$$reg_{MZ}^{NH4} = [1 - fp] \cdot \left[\frac{1}{CN_{BC}} g_{MZ/BC} + \frac{1}{CN_{PHY}} g_{MZ/NF} NFF / NF \right] - \frac{1}{CN_{MZ}} \mu_{MZ} \quad (23)$$

$$reg_{MZ}^{PO4} = [1 - fp] \cdot \left[\frac{1}{CP_{BC}} g_{MZ/BC} + \frac{1}{CP_{PHY}} g_{MZ/NF} NFF / NF \right] - \frac{1}{CP_{MZ}} \mu_{MZ} \quad (24)$$

Copepods

Grazing

$$g_{CP} = g_{\max}^{CP} \frac{DA^2 + MZ^2}{[k_g^{CP}]^2 + DA^2 + MZ^2} CP \quad (25)$$

$$g_{CP/DA} = g_{CP} \frac{DA}{DA + MZ}$$

$$g_{CP/MZ} = g_{CP} \frac{MZ}{DA + MZ}$$

Growth

$$\mu_{CP} = y_{CP} \cdot g_{CP} \quad (26)$$

Mortality

$$lys_{CP} = kd_{CP} \cdot CP^2 \quad (27)$$

Egestion

$$eg_{CP} = fp_{CP} \cdot g_{CP} \quad (28)$$

Excretion and nutrient regeneration

$$ex_{CP} = [1 - fp] g_{CP} - \mu_{CP} \quad (29)$$

$$reg_{CP}^{NH4} = [1 - fp] \cdot \left[\frac{1}{CN_{MZ}} g_{CP/MZ} + \frac{1}{CN_{PHY}} g_{CP/DA} DAF / DA \right] - \frac{1}{CN_{CP}} \mu_{CP} \quad (30)$$

$$reg_{CP}^{PO4} = [1 - fp] \cdot \left[\frac{1}{CP_{MZ}} g_{CP/MZ} + \frac{1}{CP_{PHY}} g_{CP/DA} DAF / DA \right] - \frac{1}{CP_{CP}} \mu_{CP} \quad (31)$$

Microbial loop

Bacteria

Growth

$$\mu_{BC} = y_{BC} \cdot upt_{BC} \quad (32)$$

Carbon and nutrient uptake

$$upt_{BC}^{BSC} = b_{\max} \frac{S^{ut}}{S^{ut} + k_{BSC}} BC \quad (33)$$

where $S^{ut} = BSC - 0.1 \cdot k_{BSC}$

Carbon and nutrient uptake (continued)
N uptake

$$upt_{BC}^{N} = upt_{BC}^{BSC} \cdot \frac{BSN}{BSC} \quad (34)$$

P uptake

$$upt_{BC}^{PO4} = \frac{1}{CP_{BC}} \mu_{BC} \quad (35)$$

N regeneration (ammonification)

$$reg_{BC}^{NH4} = upt_{BC}^{N} - \frac{1}{CN_{BC}} \mu_{BC} \quad (36)$$

Nitrification

$$ni = ni_{\max} \frac{NH_4}{NH_4 + k_{ni}^{NH4}} \quad (37)$$

Lysis

$$lys_{BC} = k_d^{BC} \; BC \quad (38)$$

Organic matter
i: (1) labile polymers; (2) semi-labile polymers
Ecto-hydrolysis of dissolved polymers

$$elys_{DC_i} = ei_{\max} \frac{DCi}{DCi + ki_h} BC \quad (39)$$

$$elys_{DNi} = elys_{DCi} \frac{DNi}{DCi} \quad (40)$$

$$elys_{DPi} = elys_{DCi} \frac{DPi}{DCi} \quad (41)$$

Hydrolysis of particulate organic matter

$lys_{PCi} = k_i b \cdot PCi$ (42)
$lys_{PNi} = k_i b \cdot PNi$ (43)
$lys_{PPi} = k_i b \cdot PPi$ (44)
$lys_{BSi} = k_i b \cdot BSi$ (45)

Sedimentation of particulate organic matter

$sed_{PCi} = k_{sed} \cdot PCi$ (46)
$sed_{PNi} = k_{sed} \cdot PNi$ (47)
$sed_{PPi} = k_{sed} \cdot PPi$ (48)

Benthic processes (other than organic matter degradation)
Nitrification

$$ni^B = ni_{\max}^B NH_4 \quad (49)$$

Ammonium adsorption/desorption

$$ads_{NH4}^B = k_{am} NH_4 \quad (50)$$

Phosphate adsorption/desorption

Oxic layer

$$ads_{PO4}^B = k_{pa} PO_4 \quad (51)$$

Anoxic layer

$$ads_{PO4}^B = k_{pe} PO_4 \quad (52)$$

Temperature dependence of physiological parameters

$$p = p^* \cdot e^{\left[-\frac{[T - T_{opt}]^2}{dti^2}\right]} \quad (53)$$

Appendix 5. The MIRO model: parameters. *Temperature-dependent; **nutrient stress-dependent. State variables: F (functional and structural metabolites), R (reserve products), S (monomers)

Symbol	Description	Unit	Value	Origin and source
Phytoplankton				
Carbon metabolism losses				
k_{max}^{DA}*	Max. photosynthetic capacity rate of DA at optimal temperature	h^{-1}	0.12	Estimated from photosynthesis–light relationship data (C. Lancelot & V. Rousseau unpubl.)
k_{max}^{NF}*	Max. photosynthetic capacity rate of NF at optimal temperature	h^{-1}	0.10	Estimated from photosynthesis–light relationship data (C. Lancelot & V. Rousseau unpubl.)
k_{max}^{OP}*	Max. photosynthetic capacity rate of OP at optimal temperature	h^{-1}	0.30	Estimated from photosynthesis–light relationship data (Lancelot & Mathot 1987)
I_k	Light adaptation parameter	µmol m^{-2} s^{-1}	20 to 65	Photo-adaptation to ambient light (Lancelot et al. 1991)
smu_{max}*	Max. rate of OP mucus synthesis	h^{-1}	0.20	Estimated from photosynthesis–light relationship data (Lancelot & Mathot 1987)
μ_{max}^{DA}*	Max. F synthesis rate of DA at optimal temperature	h^{-1}	0.05	Estimated from temperature dependence (protein synthesis) experiments (Lancelot et al. 1998)
μ_{max}^{NF}*	Max. F synthesis rate of NF at optimal temperature	h^{-1}	0.09	Estimated from temperature dependence (protein synthesis) experiments (Lancelot et al. 1998)
μ_{max}^{OP}*	Max. F synthesis rate of OP at optimal temperature	h^{-1}	0.09	Estimated from temperature dependence (protein synthesis) experiments (Lancelot et al. 1998, Schoemann et al. 2004)
sr_{max}^{DA}*	Max. R synthesis rate of DA at optimal temperature	h^{-1}	0.10	Estimated from best fitting of ^{14}C time-course exp. (e.g. Lancelot & Mathot 1985a, Mathot et al. 1992) using AQUAPHY equations
sr_{max}^{NF}*	Max. R synthesis rate of NF at optimal temperature	h^{-1}	0.10	Estimated from best fitting of ^{14}C time-course exp. (e.g. Mathot et al. 1992) using AQUAPHY's equations
sr_{max}^{OP}*	Max. R synthesis rate of OP at optimal temperature	h^{-1}	0.10	Estimated from best fitting of ^{14}C time-course exp. (e.g. Lancelot & Mathot 1985b, Mathot et al. 1992) using AQUAPHY equations
k_s	Half saturation constant of S assimilation	mgC:mgC	0.06	Adjusted from ^{14}C experiments (Mathot et al. 1992)
k_{cR}^{DA}	Specific rate of DAR catabolism	h^{-1}	0.06	Estimated from best fitting of ^{14}C time-course experiment using AQUAPHY equations (e.g. Lancelot & Mathot 1985a, Mathot et al. 1992)
k_{cR}^{NF}	Specific rate of NFR catabolism	h^{-1}	0.06	Estimated from best fitting of ^{14}C time-course exp. (e.g. Mathot et al. 1992) using AQUAPHY equations
k_{cR}^{OP}	Specific rate of OPR catabolism	h^{-1}	0.06	Estimated from best fitting of ^{14}C time-course exp. (e.g. Lancelot & Mathot 1985b, Mathot et al. 1992) using AQUAPHY equations
k_F^{DA}	Constant of DA cell maintenance	h^{-1}	0.0004	Diatoms cultures in the dark (Verity 1982)
k_F^{NF}	Constant of NF cell maintenance	h^{-1}	0.0008	Estimated
k_F^{OP}	Constant of OP cell maintenance	h^{-1}	0.0008	Estimated
ecs_{NO3}	Energy cost of F synthesis (NO_3 source)	mol C:mol C	0.8	Penning-De Vries et al. (1974)
ecs_{NO4}	Energy cost of F synthesis (NH_4 source)	mol C:mol C	0.4	Penning-De Vries et al. (1974)
ε	Excretion constant	h^{-1}	0.001	Average from photosynthesis/excretion light curves (Lancelot 1979, 1983)
k_{lys}^{DA}** $_{min}$	Minimum specific rate of DA cellular autolysis	h^{-1}	0.0016	Adjusted based on Brussaard et al. (1995)
k_{lys}^{NF}** $_{min}$	Minimum specific rate of NF cellular autolysis	h^{-1}	0.0025	Adjusted based on Brussaard et al. (1995)
k_{lys}^{OPC}** $_{min}$	Minimum specific rate of 0P cellular autolysis	h^{-1}	0.003	Adjusted based on Brussaard et al. (1995)
$k_{lyscol_{min}}$	Minimum specific rate of colony lysis	h^{-1}	0.002	Adjusted
$k_{lyscol_{max}}$	Max. specific rate of colony lysis for $\frac{OPF}{OPM} > 1.7$	h^{-1}	0.02	
aggr	Fraction of colony lysis products that aggregates	Dimensionless	0.25	Adjusted
k_{sed}^{DA}** $_{min}$	Minimum diatom (DA) sinking rate	m h^{-1}	0.0085	SetCol experiments (Lancelot et al. 2004)
k_{sed}^{OP}** $_{min}$	Minimum *Phaecystis* colony (OP) sinking rate	m h^{-1}	0.0085	SetCol experiments (Lancelot et al. 2004)

Appendix 5 (continued)

Symbol	Description	Unit	Value	Origin and source
Nutrient uptake				
k_N^{DA}	Half saturation constant for DIN uptake (DA)	mmol N m^{-3}	0.80	Size-adjusted from literature (Stolte 1996)
k_N^{NF}	Half saturation constant for DIN uptake (NF)	mmol N m^{-3}	0.50	Size-adjusted from literature (Stolte 1996)
k_N^{OP}	Half saturation constant for DIN uptake (OP)	mmol N m^{-3}	2	Size-adjusted from literature (Lancelot et al. 1986, Stolte 1996)
i_m	Max. rate of NO_3 uptake inhibition by NH_4	mmol N:mmol N	0.8	Elskens et al. (1997)
k_i	Half saturation constant of NO_3 uptake inhibition by NH_4	mmol N m-3	0.57	Tungeraza (2000)
k_P^{DA}	Half saturation constant for PO_4 uptake (DA)	mmol P m^{-3}	0.3	Size-adjusted from literature
k_P^{NF}	Half saturation constant for PO_4 uptake (NF)	mmol P m^{-3}	0.1	Size-adjusted from literature
k^{OP}	Half saturation constant for PO_4 uptake (OP)	mmol P m^{-3}	0.001	Chosen very low to consider ability to use organic P (Veldhuis et al. 1991)
k_{DSi}^{DA}	Half saturation constant for Si uptake (DA)	mmol Si m^{-3}	0.40	Adjusted to average minimum ambient concentration at 330
Cellular stoichiometry				
CChl	Chl *a*:C ratio for F metabolites	mg chl:mg C	0.04	Estimated from biochemical composition of field phytoplankton (growing phase) (Lancelot-Van Beveren 1980)
CN_{PHY}	C:N ratio for F metabolites	mmol C:mmol N	4.10	Estimated from protein and chl *a* content of field phytoplankton (growing phase) (Lancelot-Van Beveren 1980)
CP_{PHY}	C:P ratio for F metabolites	mmol C:mmol P	65	Biochemical composition (Lancelot-Van Beveren 1980, Redfield et al. 1963)
SiC	Si:C ratio for DAF metabolites	mmol Si:mmol C		Rousseau et al. (2002)
	Days 1 to 150 early spring diatom		0.36	
	Days 151 to 365: spring-summer diatoms		0.11	
Temperature adaptation				
T_{opt}^{DA}	*DA* optimal growth temperature	°C	5.5	Lancelot et al. (1998), Rousseau (2000)
	Days 1 to 150 early spring diatom		15	
	Days 151 to 365: spring-summer diatoms			
T_{opt}^{NF}	*NF* optimal growth temperature	°C	15	Lancelot et al. (1998), Schoemann et al. (2004)
T_{opt}^{OP}	*OP* optimal growth temperature	°C	15	Lancelot et al. (1998), Schoemann et al. (2004)
dT_{DA}	*DA* temperature interval			
	Days 1 to 150	°C	1.6	Lancelot et al. (1998), Rousseau (2000)
	Days 151 to 365		12	
dT_{NF}	*NF* temperature interval	°C	12	Lancelot et al. (1998), Schoemann et al. (2004)
dT_{OP}	*OP* temperature interval	°C	12	Lancelot et al. 1998; Schoemann et al. (2004)
Microzooplankton MZ				
Carbon metabolism and losses				
$g_{\max}^{MZ/BC\bullet}$	Max. specific grazing rate on bacteria BC (optimal temperature)	h^{-1}	0.05	Adjusted from grazing experiments (Becquevort 1999)
$g_{\max}^{MZ/NF\bullet}$	Max. grazing rate on nanoflagellates NF (optimal temperature)	h^{-1}	0.04	Adjusted from grazing experiments (Weisse & Scheffel-Möser 1990, Becquevort 1999)
$k_{g}^{MZ/BC}$	Half saturation constant for grazing on BC	mg C m^{-3}	40	Adjusted from grazing experiments (Becquevort 1999)
$k_{g}^{MZ/NF}$	Half saturation constant for grazing on NF	mg C m^{-3}	5	Adjusted from grazing experiments (Weisse & Scheffel-Möser 1990, Becquevort 1999)
$y_{MZ/NF}$	Growth efficiency (prey = NF)	Dimensionless	0.35	Estimated from Hansen (1992)
$y_{MZ/BC}$	Growth efficiency (prey = BC)	Dimensionless	0.1	Estimated (= 0.3 × 0.3)
fp_{MZ}	Egested fraction of ingestion	Dimensionless	0.25	Arbitrary
$k_d^{MZ\bullet}$	Mortality rate	h^{-1}	0.002	Estimated from Billen et al (1990)
Cellular stoichiometry				
CN_{MZ}	C:N ratio	mg C:mmol N	63	Redfield et al. (1963)
NP_{MZ}	N:P ratio	mol N:mol P	16	Redfield et al. (1963)
CP_{MZ}	C:P ratio	mg C:mmol P	1008	Redfield et al. (1963)
Temperature adaptation				
T_{opt}^{MZ}	Optimal temperature	°C	15	Adjusted to prey temperature dependence
dT_{MZ}	Temperature interval	°C	12	Adjusted to prey temperature dependence

Appendix 5 (continued)

Symbol	Description	Unit	Value	Origin and source
Copepods: CP				
Carbon metabolism and losses				
$g_{\max}^{CP}$*	Max. specific grazing rate (optimal temperature)	h^{-1}	0.04	Estimated from grazing data (Daro 1985)
k_g^{CP}	Half-saturation constant for grazing on DA+ MZ	mg C m^{-3}	50	Estimated from grazing data (Daro 1985)
y_{CP}	Growth efficiency	Dimensionless	0.25	Hecq (1981)
fp_{CP}	Egested fraction of ingestion	Dimensionless	0.25	Average from literature
kd_{CP}*	Mortality rate	h^{-1}	0.0003	Adjusted (quadratic closure term)
Cellular stoichiometry				
CN_{CP}	C:N ratio	mg C:mmol N	63	Redfield et al. (1963)
NP_{CP}	N:P ratio	mol N:mol P	16	Redfield et al. (1963)
CP_{CP}	C:P ratio	mg C:mmol P	1008	Redfield et al. (1963)
Temperature adaptation				
T_{opt}^{CP}	Optimal growth temperature	°C	16	Adjusted from observed seasonal cycle (Hecq 1981)
dT_{CP}	Temperature interval	°C	12	Adjusted from observed seasonal cycle (Hecq 1981)
Microbial loop				
Organic matter				
ε_{D1}	Labile DOM (D1) share of lysis products	Dimensionless	0.3	Adjusted
ε_{D2}	Semi-labile DOM (D2) share of lysis products	Dimensionless	0.2	Adjusted
ε_{P1}	Labile POM (P1) share of lysis products	Dimensionless	0.1	Adjusted
ε_{P2}	Semi-labile POM (P2) share of lysis products	Dimensionless	0.4	Adjusted
τ_{d1}	Labile DOM share of OPM lysis products	Dimensionless	0.5	Adjusted
τ_{p1}	Labile POM share of OP aggregates	Dimensionless	0.5	Adjusted
$\gamma_{D1}^{CP,MZ}$	Labile DOM share of fecal pellets	Dimensionless	0.1	Adjusted
$\gamma_{D2}^{CP,MZ}$	Semi-labile DOM share of fecal pellets	Dimensionless	0.2	Adjusted
$\gamma_{P1}^{CP,MZ}$	Labile POM share of fecal pellets	Dimensionless	0.3	Adjusted
$\gamma_{P2}^{CP,MZ}$	Semi-labile POM share of fecal pellets	Dimensionless	0.4	Adjusted
Bacterioplankton				
$e1_{\max}$*	Max. specific rate of D1 ecto-enzymatic hydrolysis at optimal temperature	h^{-1}	0.75	Microbial bio-assay (Billen & Servais 1989)
$e2_{\max}$*	Max. specific rate of D2 ecto-enzymatic hydrolysis at optimal temperature	h^{-1}	0.25	Microbial bio-assay (Billen & Servais 1989)
$k1_h$	Half saturation constant for D1 ecto- enzymatic hydrolysis	mg C m^{-3}	250	Microbial bio-assay (Billen & Servais 1989)
$k2_h$	Half saturation constant for D2 ecto- enzymatic hydrolysis	mg C m^{-3}	2500	Microbial bio-assay (Billen & Servais 1989)
$b_{\max}$*	Max. specific rate of BS uptake at optimal temperature	h^{-1}	0.6	Microbial bio-assay (Billen & Servais 1989)
k_{BSC}	Half saturation constant for BSC uptake	mg C m^{-3}	25	Microbial bio-assay (Billen & Servais 1989)
y_{BC}	Growth efficiency	Dimensionless	0.2	Mean estimate from North Sea data (Billen et al. 1991)
k_d^{BSC}*	Autolysis specific rate at optimal temperatue	h^{-1}	0.01	Adjusted
$ni_{\max}$	Max. rate of nitrification	mmol N m^{-3} h^{-1}	0.03	Unknown & Adjusted for BCZ
k_{ni}^{NH4}	Half saturation constant for nitrification	mmol N m^{-3}	5	Unknown & Adjusted for BCZ
Cellular stoichiometry				
CN_{BC}	C:N ratio	mg C:mmol N	56	Compilation (Kirchman 2000)
NP_{BC}	N:P ratio	mol N:mol P	16	Redfield et al. (1963)
CP_{BC}	C:P ratio	mg C:mmol P	896	Redfield et al. (1963), Kirchman (2000)
Temperature adaptation				
T_{opt}^{BC}	Optimal temperature	°C	30	Compilation for temperate systems (Billen et al. 1991)
dT_{BC}	Temperature interval	°C	18	Compilation for temperate systems (Billen et al. 1991)
POM degradation and benthic diagenesis				
D_i	Apparent diffusion coefficient (interstitial phase)	m^2 h^{-1}	1.8×10^{-5}	Fick's law
D_s	Mixing coefficient (solid phase)	m^2 h^{-1}	1.8×10^{-6}	Fick's law
k_{1b}*	Hydrolysis rate of PC_1 at T_{opt}	h^{-1}	0.005	Billen et al. (1989)
k_{2b}	Hydrolysis rate of PC_2	h^{-1}	0.00025	Billen et al. (1989)
k_{1p}*	Hydrolysis rate of PP_1 at T_{opt}	h^{-1}	0.05	Billen et al. (1989)
k_{2p}	Hydrolysis rate of PP_2	h^{-1}	0.0025	Billen et al. (1989)
k_{BSi}	Biogenic silica dissolution rate	h^{-1}	0.0002	Adjusted
$ni_{\max}^{B}$	Benthic nitrification constant	Dimensionless	1	Billen et al. (1989)
k_{am}	NH_4 adsorption constant	Dimensionless	6	Adjusted from Krom & Berner (1980a)
k_{pa}	PO_4 adsorption constant (oxic layer)	Dimensionless	1	Adjusted
k_{pe}	PO_4 adsorption constant (anoxic layer)	Dimensionless	0.5	Adjusted from Krom & Berner (1980a,b)
T_{opt}^{BC}	Optimal temperature	°C	30	Identical to planktonic bacteria
dT_{BC}	Temperature interval	°C	18	Identical to planktonic bacteria

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