BSH-ERGOM (of HBM-ERGOM) (v2017)
Documentation

T. Neumann, M. Maar, T. Bruenning, I. Lorkowski, F. Schwichtenberg, D. Neumann

June 26, 2018

Contents

1 Introduction

This is an automatically generated description of the ecosystem model BSH-ERGOM (of HBM-ERGOM) version v2017 . Model formulation is provided by text files in compliance with the rules of the Code Generation Tool (CGT) by Hagen Radtke (see www.ergom.net).

The model consists of a set of state variables, the so called tracers. They are defined and described in Chapter 2.

The following Chapter 3 is the main part of this model description document, since it describes the processes which change the tracer concentrations over time. They are defined analog to chemical processes, two components describe their action:

- A process equation which describes the transformation from precursors (on the left-hand side) to products (on the right-hand side), and
- a turnover rate, describing how fast the process runs.

The rate at which a process changes a tracer can then easily be determined by multiplying the process turnover rate with the stochiometric ratio in which it consumes or produces the tracer according to the reaction equation.

We structured the documentation into different process types to keep the documentation readable. So all processes belonging to one type (e.g. phytoplankton assimilation) are listed together with their constants and auxiliary variables they depend on. This means that some constants, such as stochiometric ratios, will occur several times in this documentation, making it longer. We take this compromise for the sake of readability, keeping all information required to understand a specific process in its own section.

The classical way of describing an ecosystem model is by giving the tracer equations. We still do this in the last chapter for the sake of completeness, but rather suggest to stick to Chapter 3 to understand the model, and see Chapter 4 as a supplement only.

2 Description of model state variables (tracers)

Tracers in the water column only	
amm	**ammonium (mol/kg)**
nit	**nitrate (mol/kg)**
phos	**phosphate (mol/kg)**
sil	**silicate (mol/kg)**
dia	**diatoms (mol/kg)**
vertical speed =	-0.2 m/day
opacity =	1.0 m^2/mol
flag	**flagellates (mol/kg)**
opacity =	1.0 m^2/mol
cyano	**cyano bacteria (mol/kg)**
vertical speed =	0.1 m/day
opacity =	1.0 m^2/mol
mez	**meso zooplankton (mol/kg)**
miz	**micro zooplakton (mol/kg)**
det	**Detritus (mol/kg)**
vertical speed =	-1.5 m/day
opacity =	1.0 m^2/mol
dets	**S-Detritus (mol/kg)**
vertical speed =	-1.5 m/day
ldon	**ldon is the labile DON fraction (mol/kg)**
oxy	**Oxygen (mol/kg)**
amm_with_ship_N	**ammonium; containing (mol/kg)**
nit_with_ship_N	**nitrate; containing (mol/kg)**

continued on next page...

Tracers in the water column only, continued from previous page	
`dia_with_ship_N`	**diatoms; containing (mol/kg)**
vertical speed =	-0.2 m/day
`flag_with_ship_N`	**flagellates; containing (mol/kg)**
`cyano_with_ship_N`	**cyano bacteria; containing (mol/kg)**
vertical speed =	0.1 m/day
`mez_with_ship_N`	**meso zooplankton; containing (mol/kg)**
`miz_with_ship_N`	**micro zooplakton; containing (mol/kg)**
`det_with_ship_N`	**Detritus; containing (mol/kg)**
vertical speed =	-1.5 m/day
`ldon_with_ship_N`	**ldon is the labile DON fraction; containing (mol/kg)**
`amm_with_river_N`	**ammonium; containing (mol/kg)**
`nit_with_river_N`	**nitrate; containing (mol/kg)**
`dia_with_river_N`	**diatoms; containing (mol/kg)**
vertical speed =	-0.2 m/day
`flag_with_river_N`	**flagellates; containing (mol/kg)**
`cyano_with_river_N`	**cyano bacteria; containing (mol/kg)**
vertical speed =	0.1 m/day
`mez_with_river_N`	**meso zooplankton; containing (mol/kg)**
`miz_with_river_N`	**micro zooplakton; containing (mol/kg)**
`det_with_river_N`	**Detritus; containing (mol/kg)**
vertical speed =	-1.5 m/day
`ldon_with_river_N`	**ldon is the labile DON fraction; containing (mol/kg)**
Tracers in water and pore water	
Tracers in fluff and sediment	
`nitr`	**nitrogen in the sediment (mol/m^2)**
`sili`	**silicate in the sediment (mol/m^2)**
`nitr_with_ship_N`	**nitrogen in the sediment; containing (mol/m^2)**

continued on next page...

Tracers in fluff and sediment, continued from previous page

`nitr_with_river_N`	**nitrogen in the sediment; containing (mol/m^2)**

3 Description of model processes, ordered by process type

3.1 Process type standard

Processes
nitrification (sediment only) [mol/m^2/day]
`ONnitr*NOR*oxy + amm ->`
`fnitr*recs*nitr*theta(oxy)`
`nitrification_amm_se`
`=`
mineralization of bentic nitrogen, mmol N/m2/d (sediment only) [mol/m^2/day]
`nitr + ldn_N_sed*nit + NOR*ldn_O_sed*oxy -> amm + rfr*one_pburial*phos`
`recs * nitr`
`mineralization_nitr_`
`=`
mineralization of bentic silicate, mmol N/m2/d (sediment only) [mol/m^2/day]
`sili ->`
`recs * sili`
`mineralization_sili_`
`=`
Grazing of micro-zooplankton on diatoms [mol/kg/day]
`dia -> miz + rfs*dets`
`grazing_miz_on_dia  mizprefdia * miztotgraz * miz * dia`
`=`
Grazing of micro-zooplankton on flaggelates [mol/kg/day]
`flag -> miz`
`grazing_miz_on_flag mizprefflag * miztotgraz * miz * flag`
`=`
Grazing of micro-zooplankton on cyano [mol/kg/day]
`cyano -> miz`
`mizprefcyano * miztotgraz * miz * cyano`
`grazing_miz_on_cyanc`
`=`
respiration of micro-zooplankton [mol/kg/day]
`NOR*ONamup*oxy + miz -> ldon_frac*ldon + (one-ldon_frac)*amm + rfr*phos`

continued on next page...

Processes, continued from previous page

```
respiration_miz =   lnmiz * miztotgraz * foodmiz * miz
```

mortality of micro-zooplankton [mol/kg/day]

```
miz -> det
mortality_miz =     tldmiz * miz
```

Grazing of meso-zooplankton on diatoms [mol/kg/day]

```
dia -> mez + rfs*dets
grazing_mez_on_dia  mezprefdia * meztotgraz * mez * dia
=
```

Grazing of meso-zooplankton on flaggelates [mol/kg/day]

```
flag -> mez
grazing_mez_on_flag mezprefflag * meztotgraz * mez * flag
=
```

Grazing of meso-zooplankton on cyano [mol/kg/day]

```
cyano -> mez
                    mezprefcyano * meztotgraz * mez * cyano
grazing_mez_on_cyanc
=
```

Grazing of meso-zooplankton on micro-zooplankton [mol/kg/day]

```
miz -> mez
grazing_mez_on_miz  mezprefmiz * meztotgraz * mez * miz
=
```

respiration of meso-zooplankton [mol/kg/day]

```
NOR*ONamup*oxy + mez -> rfr*phos + (one-ldon_frac)*amm + ldon_frac*ldon
respiration_mez =   lnmez * meztotgraz * foodmez * mez
```

mortality of meso-zooplankton [mol/kg/day]

```
mez -> det
mortality_mez =     tldmez * mez
```

uptake of ammonium (, phosphate and silicate) by diatoms [mol/kg/day]

```
rfs*sil + rfr*phos + amm -> NOR*ONamup*oxy + dia
uptake_amm_by_dia = rp * (dia+p0) * amm * invdin_eps
```

uptake of nitrate (, phosphate and silicate) by diatoms [mol/kg/day]

```
rfs*sil + rfr*phos + nit -> NOR*ONniup*oxy + dia
uptake_nit_by_dia = rp * (dia+p0) * nit * invdin_eps
```

respiration of diatoms [mol/kg/day]

```
dia + NOR*ONamup*oxy -> ldon_frac*ldon + (one-ldon_frac)*amm + rfr*phos + rfs*
sil
```

continued on next page...

Processes, continued from previous page

```
respiration_dia =   lpn * dia
```

mortality of diatoms [mol/kg/day]

```
dia -> det + rfs*dets
mortality_dia =     lpd * dia
```

uptake of ammonium (and phosphate) by flagellates [mol/kg/day]

```
rfr*phos + amm -> flag + NOR*ONamup*oxy
uptake_amm_by_flag  rf * (flag+f0) * amm * invdin_eps
=
```

uptake of nitrate (and phosphate) by flagellates [mol/kg/day]

```
nit + rfr*phos -> flag + NOR*ONniup*oxy
uptake_nit_by_flat  rf * (flag+f0) * nit * invdin_eps
=
```

respiration of flagelattes [mol/kg/day]

```
flag + NOR*ONamup*oxy -> ldon_frac*ldon + (one-ldon_frac)*amm + rfr*phos
respiration_flag =  lpn * flag
```

mortality of flagellates [mol/kg/day]

```
flag -> det
mortality_flag =    lpd * flag
```

uptake of phosphate by cyano bacteria [mol/kg/day]

```
rfr*phos -> NOR*ONamup*oxy + cyano
                    rb * (cyano + b0)
uptake_phos_by_cyanc
=
```

respiration of cyano bacteria [mol/kg/day]

```
NOR*ONamup*oxy + cyano -> rfr*phos + (one-ldon_frac)*amm + ldon_frac*ldon
respiration_cyano = lpn * cyano
```

mortality of cyano bacteria [mol/kg/day]

```
cyano -> det
mortality_cyano =   lpd * cyano
```

recycling of detritus [mol/kg/day]

```
det + ldn_N*nit + NOR*ldn_O*oxy -> amm + rfr*phos
                    ldn * det
recycling_detritus_t
=
```

recycling of detritus [mol/kg/day]

```
dets -> sil
```

continued on next page...

Processes, continued from previous page

```
                    lds * dets
recycling_detritus_t
=
```

nitrification [mol/kg/day]

```
NOR*ONnitr*oxy + amm -> nit
nitrification =     nf * amm
```

degradation of lDON [mol/kg/day]

```
ldon -> amm
degradation_ldon =  ldon_tor * ldon
```

nitrification; sub-process for ship nitrogen (sediment only) [mol/m^2/day]

```
 ->
                    nitrification_amm_sed * ((1.0)*(1)*
nitrification_amm_semax(0.0,min(1.0,amm_with_ship_N/max(0.00000000001,amm)))) /
=                   ((1.0)*(1))
```

mineralization of bentic nitrogen, mmol N/m2/d; sub-process for ship nitrogen (sediment only) [mol/m^2/day]

```
 -> amm_with_ship_N
                    mineralization_nitr_sed * ((1.0)*(1)*
mineralization_nitr_max(0.0,min(1.0,nitr_with_ship_N/max(0.00000000001,nitr)))+
=                   (ldn_N_sed)*(1)*
                    max(0.0,min(1.0,nit_with_ship_N/max(0.00000000001,nit)))) /
                    ((1.0)*(1)+(ldn_N_sed)*(1))
```

Grazing of micro-zooplankton on diatoms; sub-process for ship nitrogen [mol/kg/day]

```
 -> miz_with_ship_N
                    grazing_miz_on_dia * ((1.0)*(1)*
grazing_miz_on_dia_smax(0.0,min(1.0,dia_with_ship_N/max(0.00000000001,dia)))) /
=                   ((1.0)*(1))
```

Grazing of micro-zooplankton on flaggelates; sub-process for ship nitrogen [mol/kg/day]

```
 -> miz_with_ship_N
                    grazing_miz_on_flag * ((1.0)*(1)*
grazing_miz_on_flag_max(0.0,min(1.0,flag_with_ship_N/max(0.00000000001,flag))))
=                   / ((1.0)*(1))
```

Grazing of micro-zooplankton on cyano; sub-process for ship nitrogen [mol/kg/day]

```
 -> miz_with_ship_N
                    grazing_miz_on_cyano * ((1.0)*(1)*
grazing_miz_on_cyancmax(0.0,min(1.0,cyano_with_ship_N/max(0.00000000001,cyano))
=                   )) / ((1.0)*(1))
```

continued on next page...

Processes, continued from previous page

respiration of micro-zooplankton; sub-process for ship nitrogen [mol/kg/day]

```
 -> ldon_frac*ldon_with_ship_N + (one-ldon_frac)*amm_with_ship_N
                    respiration_miz * ((1.0)*(1)*
respiration_miz_ship_max(0.0,min(1.0,miz_with_ship_N/max(0.00000000001,miz)))) /
=                   ((1.0)*(1))
```

mortality of micro-zooplankton; sub-process for ship nitrogen [mol/kg/day]

```
 -> det_with_ship_N
                    mortality_miz * ((1.0)*(1)*
mortality_miz_ship_N_max(0.0,min(1.0,miz_with_ship_N/max(0.00000000001,miz)))) /
=                   ((1.0)*(1))
```

Grazing of meso-zooplankton on diatoms; sub-process for ship nitrogen [mol/kg/day]

```
 -> mez_with_ship_N
                    grazing_mez_on_dia * ((1.0)*(1)*
grazing_mez_on_dia_s_max(0.0,min(1.0,dia_with_ship_N/max(0.00000000001,dia)))) /
=                   ((1.0)*(1))
```

Grazing of meso-zooplankton on flaggelates; sub-process for ship nitrogen [mol/kg/day]

```
 -> mez_with_ship_N
                    grazing_mez_on_flag * ((1.0)*(1)*
grazing_mez_on_flag_max(0.0,min(1.0,flag_with_ship_N/max(0.00000000001,flag))))
=                   / ((1.0)*(1))
```

Grazing of meso-zooplankton on cyano; sub-process for ship nitrogen [mol/kg/day]

```
 -> mez_with_ship_N
                    grazing_mez_on_cyano * ((1.0)*(1)*
grazing_mez_on_cyanc_max(0.0,min(1.0,cyano_with_ship_N/max(0.00000000001,cyano))
=                   )) / ((1.0)*(1))
```

Grazing of meso-zooplankton on micro-zooplankton; sub-process for ship nitrogen [mol/kg/day]

```
 -> mez_with_ship_N
                    grazing_mez_on_miz * ((1.0)*(1)*
grazing_mez_on_miz_s_max(0.0,min(1.0,miz_with_ship_N/max(0.00000000001,miz)))) /
=                   ((1.0)*(1))
```

respiration of meso-zooplankton; sub-process for ship nitrogen [mol/kg/day]

```
 -> ldon_frac*ldon_with_ship_N + (one-ldon_frac)*amm_with_ship_N
                    respiration_mez * ((1.0)*(1)*
respiration_mez_ship_max(0.0,min(1.0,mez_with_ship_N/max(0.00000000001,mez)))) /
=                   ((1.0)*(1))
```

continued on next page...

Processes, continued from previous page

mortality of meso-zooplankton; sub-process for ship nitrogen [mol/kg/day]

```
 -> det_with_ship_N
                    mortality_mez * ((1.0)*(1)*
mortality_mez_ship_Nmax(0.0,min(1.0,mez_with_ship_N/max(0.00000000001,mez)))) /
=                   ((1.0)*(1))
```

uptake of ammonium (, phosphate and silicate) by diatoms; sub-process for ship nitrogen [mol/kg/day]

```
 -> dia_with_ship_N
                    uptake_amm_by_dia * ((1.0)*(1)*
uptake_amm_by_dia_shmax(0.0,min(1.0,amm_with_ship_N/max(0.00000000001,amm)))) /
=                   ((1.0)*(1))
```

uptake of nitrate (, phosphate and silicate) by diatoms; sub-process for ship nitrogen [mol/kg/day]

```
 -> dia_with_ship_N
                    uptake_nit_by_dia * ((1.0)*(1)*
uptake_nit_by_dia_shmax(0.0,min(1.0,nit_with_ship_N/max(0.00000000001,nit)))) /
=                   ((1.0)*(1))
```

respiration of diatoms; sub-process for ship nitrogen [mol/kg/day]

```
 -> ldon_frac*ldon_with_ship_N + (one-ldon_frac)*amm_with_ship_N
                    respiration_dia * ((1.0)*(1)*
respiration_dia_shipmax(0.0,min(1.0,dia_with_ship_N/max(0.00000000001,dia)))) /
=                   ((1.0)*(1))
```

mortality of diatoms; sub-process for ship nitrogen [mol/kg/day]

```
 -> det_with_ship_N
                    mortality_dia * ((1.0)*(1)*
mortality_dia_ship_Nmax(0.0,min(1.0,dia_with_ship_N/max(0.00000000001,dia)))) /
=                   ((1.0)*(1))
```

uptake of ammonium (and phosphate) by flagellates; sub-process for ship nitrogen [mol/kg/day]

```
 -> flag_with_ship_N
                    uptake_amm_by_flag * ((1.0)*(1)*
uptake_amm_by_flag_smax(0.0,min(1.0,amm_with_ship_N/max(0.00000000001,amm)))) /
=                   ((1.0)*(1))
```

uptake of nitrate (and phosphate) by flagellates; sub-process for ship nitrogen [mol/kg/day]

```
 -> flag_with_ship_N
                    uptake_nit_by_flat * ((1.0)*(1)*
uptake_nit_by_flat_smax(0.0,min(1.0,nit_with_ship_N/max(0.00000000001,nit)))) /
=                   ((1.0)*(1))
```

continued on next page...

Processes, continued from previous page

respiration of flagelattes; sub-process for ship nitrogen [mol/kg/day]

```
 -> ldon_frac*ldon_with_ship_N + (one-ldon_frac)*amm_with_ship_N
                    respiration_flag * ((1.0)*(1)*
respiration_flag_shimax(0.0,min(1.0,flag_with_ship_N/max(0.00000000001,flag))))
=                   / ((1.0)*(1))
```

mortality of flagellates; sub-process for ship nitrogen [mol/kg/day]

```
 -> det_with_ship_N
                    mortality_flag * ((1.0)*(1)*
mortality_flag_ship_max(0.0,min(1.0,flag_with_ship_N/max(0.00000000001,flag))))
=                   / ((1.0)*(1))
```

respiration of cyano bacteria; sub-process for ship nitrogen [mol/kg/day]

```
 -> ldon_frac*ldon_with_ship_N + (one-ldon_frac)*amm_with_ship_N
                    respiration_cyano * ((1.0)*(1)*
respiration_cyano_shmax(0.0,min(1.0,cyano_with_ship_N/max(0.00000000001,cyano))
=                   )) / ((1.0)*(1))
```

mortality of cyano bacteria; sub-process for ship nitrogen [mol/kg/day]

```
 -> det_with_ship_N
                    mortality_cyano * ((1.0)*(1)*
mortality_cyano_shipmax(0.0,min(1.0,cyano_with_ship_N/max(0.00000000001,cyano))
=                   )) / ((1.0)*(1))
```

recycling of detritus; sub-process for ship nitrogen [mol/kg/day]

```
 -> amm_with_ship_N
                    recycling_detritus_to_n * ((1.0)*(1)*
recycling_detritus_tmax(0.0,min(1.0,det_with_ship_N/max(0.00000000001,det)))+
=                   (ldn_N)*(1)*
                    max(0.0,min(1.0,nit_with_ship_N/max(0.00000000001,nit)))) /
                    ((1.0)*(1)+(ldn_N)*(1))
```

nitrification; sub-process for ship nitrogen [mol/kg/day]

```
 -> nit_with_ship_N
                    nitrification * ((1.0)*(1)*
nitrification_ship_Nmax(0.0,min(1.0,amm_with_ship_N/max(0.00000000001,amm)))) /
=                   ((1.0)*(1))
```

degradation of lDON; sub-process for ship nitrogen [mol/kg/day]

```
 -> amm_with_ship_N
                    degradation_ldon * ((1.0)*(1)*
degradation_ldon_shimax(0.0,min(1.0,ldon_with_ship_N/max(0.00000000001,ldon))))
=                   / ((1.0)*(1))
```

continued on next page...

Processes, continued from previous page

nitrification; sub-process for river nitrogen (sediment only) [mol/m^2/day]

```
 ->
                    nitrification_amm_sed * ((1.0)*(1)*
nitrification_amm_semax(0.0,min(1.0,amm_with_river_N/max(0.00000000001,amm))))
=                   / ((1.0)*(1))
```

mineralization of bentic nitrogen, mmol N/m2/d; sub-process for river nitrogen (sediment only) [mol/m^2/day]

```
 -> amm_with_river_N
                    mineralization_nitr_sed * ((1.0)*(1)*
mineralization_nitr_max(0.0,min(1.0,nitr_with_river_N/max(0.00000000001,nitr)))
=                   +(ldn_N_sed)*(1)*
                    max(0.0,min(1.0,nit_with_river_N/max(0.00000000001,nit))))
                    / ((1.0)*(1)+(ldn_N_sed)*(1))
```

Grazing of micro-zooplankton on diatoms; sub-process for river nitrogen [mol/kg/day]

```
 -> miz_with_river_N
                    grazing_miz_on_dia * ((1.0)*(1)*
grazing_miz_on_dia_rmax(0.0,min(1.0,dia_with_river_N/max(0.00000000001,dia))))
=                   / ((1.0)*(1))
```

Grazing of micro-zooplankton on flaggelates; sub-process for river nitrogen [mol/kg/day]

```
 -> miz_with_river_N
                    grazing_miz_on_flag * ((1.0)*(1)*
grazing_miz_on_flag_max(0.0,min(1.0,flag_with_river_N/max(0.00000000001,flag)))
=                   ) / ((1.0)*(1))
```

Grazing of micro-zooplankton on cyano; sub-process for river nitrogen [mol/kg/day]

```
 -> miz_with_river_N
                    grazing_miz_on_cyano * ((1.0)*(1)*
grazing_miz_on_cyancmax(0.0,min(1.0,cyano_with_river_N/max(0.00000000001,cyano)
=                   ))) / ((1.0)*(1))
```

respiration of micro-zooplankton; sub-process for river nitrogen [mol/kg/day]

```
 -> ldon_frac*ldon_with_river_N + (one-ldon_frac)*amm_with_river_N
                    respiration_miz * ((1.0)*(1)*
respiration_miz_rivemax(0.0,min(1.0,miz_with_river_N/max(0.00000000001,miz))))
=                   / ((1.0)*(1))
```

mortality of micro-zooplankton; sub-process for river nitrogen [mol/kg/day]

continued on next page...

Processes, continued from previous page

```
 -> det_with_river_N
                    mortality_miz * ((1.0)*(1)*
mortality_miz_river_max(0.0,min(1.0,miz_with_river_N/max(0.00000000001,miz))))
=                   / ((1.0)*(1))
```

Grazing of meso-zooplankton on diatoms; sub-process for river nitrogen [mol/kg/day]

```
 -> mez_with_river_N
                    grazing_mez_on_dia * ((1.0)*(1)*
grazing_mez_on_dia_rmax(0.0,min(1.0,dia_with_river_N/max(0.00000000001,dia))))
=                   / ((1.0)*(1))
```

Grazing of meso-zooplankton on flaggelates; sub-process for river nitrogen [mol/kg/day]

```
 -> mez_with_river_N
                    grazing_mez_on_flag * ((1.0)*(1)*
grazing_mez_on_flag_max(0.0,min(1.0,flag_with_river_N/max(0.00000000001,flag)))
=                   ) / ((1.0)*(1))
```

Grazing of meso-zooplankton on cyano; sub-process for river nitrogen [mol/kg/day]

```
 -> mez_with_river_N
                    grazing_mez_on_cyano * ((1.0)*(1)*
grazing_mez_on_cyancmax(0.0,min(1.0,cyano_with_river_N/max(0.00000000001,cyano)
=                   ))) / ((1.0)*(1))
```

Grazing of meso-zooplankton on micro-zooplankton; sub-process for river nitrogen [mol/kg/day]

```
 -> mez_with_river_N
                    grazing_mez_on_miz * ((1.0)*(1)*
grazing_mez_on_miz_rmax(0.0,min(1.0,miz_with_river_N/max(0.00000000001,miz))))
=                   / ((1.0)*(1))
```

respiration of meso-zooplankton; sub-process for river nitrogen [mol/kg/day]

```
 -> ldon_frac*ldon_with_river_N + (one-ldon_frac)*amm_with_river_N
                    respiration_mez * ((1.0)*(1)*
respiration_mez_rivemax(0.0,min(1.0,mez_with_river_N/max(0.00000000001,mez))))
=                   / ((1.0)*(1))
```

mortality of meso-zooplankton; sub-process for river nitrogen [mol/kg/day]

```
 -> det_with_river_N
                    mortality_mez * ((1.0)*(1)*
mortality_mez_river_max(0.0,min(1.0,mez_with_river_N/max(0.00000000001,mez))))
=                   / ((1.0)*(1))
```

continued on next page...

Processes, continued from previous page

uptake of ammonium (, phosphate and silicate) by diatoms; sub-process for river nitrogen [mol/kg/day]

```
 -> dia_with_river_N
                    uptake_amm_by_dia * ((1.0)*(1)*
uptake_amm_by_dia_rimax(0.0,min(1.0,amm_with_river_N/max(0.00000000001,amm))))
=                   / ((1.0)*(1))
```

uptake of nitrate (, phosphate and silicate) by diatoms; sub-process for river nitrogen [mol/kg/day]

```
 -> dia_with_river_N
                    uptake_nit_by_dia * ((1.0)*(1)*
uptake_nit_by_dia_rimax(0.0,min(1.0,nit_with_river_N/max(0.00000000001,nit))))
=                   / ((1.0)*(1))
```

respiration of diatoms; sub-process for river nitrogen [mol/kg/day]

```
 -> ldon_frac*ldon_with_river_N + (one-ldon_frac)*amm_with_river_N
                    respiration_dia * ((1.0)*(1)*
respiration_dia_rivemax(0.0,min(1.0,dia_with_river_N/max(0.00000000001,dia))))
=                   / ((1.0)*(1))
```

mortality of diatoms; sub-process for river nitrogen [mol/kg/day]

```
 -> det_with_river_N
                    mortality_dia * ((1.0)*(1)*
mortality_dia_river_max(0.0,min(1.0,dia_with_river_N/max(0.00000000001,dia))))
=                   / ((1.0)*(1))
```

uptake of ammonium (and phosphate) by flagellates; sub-process for river nitrogen [mol/kg/day]

```
 -> flag_with_river_N
                    uptake_amm_by_flag * ((1.0)*(1)*
uptake_amm_by_flag_rmax(0.0,min(1.0,amm_with_river_N/max(0.00000000001,amm))))
=                   / ((1.0)*(1))
```

uptake of nitrate (and phosphate) by flagellates; sub-process for river nitrogen [mol/kg/day]

```
 -> flag_with_river_N
                    uptake_nit_by_flat * ((1.0)*(1)*
uptake_nit_by_flat_rmax(0.0,min(1.0,nit_with_river_N/max(0.00000000001,nit))))
=                   / ((1.0)*(1))
```

respiration of flagelattes; sub-process for river nitrogen [mol/kg/day]

```
 -> ldon_frac*ldon_with_river_N + (one-ldon_frac)*amm_with_river_N
                    respiration_flag * ((1.0)*(1)*
respiration_flag_rivmax(0.0,min(1.0,flag_with_river_N/max(0.00000000001,flag)))
=                   ) / ((1.0)*(1))
```

continued on next page...

Processes, continued from previous page

mortality of flagellates; sub-process for river nitrogen [mol/kg/day]

```
 -> det_with_river_N
                    mortality_flag * ((1.0)*(1)*
mortality_flag_rivermax(0.0,min(1.0,flag_with_river_N/max(0.00000000001,flag)))
=                   ) / ((1.0)*(1))
```

respiration of cyano bacteria; sub-process for river nitrogen [mol/kg/day]

```
 -> ldon_frac*ldon_with_river_N + (one-ldon_frac)*amm_with_river_N
                    respiration_cyano * ((1.0)*(1)*
respiration_cyano_rimax(0.0,min(1.0,cyano_with_river_N/max(0.00000000001,cyano)
=                   ))) / ((1.0)*(1))
```

mortality of cyano bacteria; sub-process for river nitrogen [mol/kg/day]

```
 -> det_with_river_N
                    mortality_cyano * ((1.0)*(1)*
mortality_cyano_rivemax(0.0,min(1.0,cyano_with_river_N/max(0.00000000001,cyano)
=                   ))) / ((1.0)*(1))
```

recycling of detritus; sub-process for river nitrogen [mol/kg/day]

```
 -> amm_with_river_N
                    recycling_detritus_to_n * ((1.0)*(1)*
recycling_detritus_tmax(0.0,min(1.0,det_with_river_N/max(0.00000000001,det)))+
=                   (ldn_N)*(1)*
                    max(0.0,min(1.0,nit_with_river_N/max(0.00000000001,nit))))
                    / ((1.0)*(1)+(ldn_N)*(1))
```

nitrification; sub-process for river nitrogen [mol/kg/day]

```
 -> nit_with_river_N
                    nitrification * ((1.0)*(1)*
nitrification_river_max(0.0,min(1.0,amm_with_river_N/max(0.00000000001,amm))))
=                   / ((1.0)*(1))
```

degradation of lDON; sub-process for river nitrogen [mol/kg/day]

```
 -> amm_with_river_N
                    degradation_ldon * ((1.0)*(1)*
degradation_ldon_rivmax(0.0,min(1.0,ldon_with_river_N/max(0.00000000001,ldon)))
=                   ) / ((1.0)*(1))
```

Auxiliary variables

```
Kspburial2 =        Kspburial*Kspburial
```

```
oxy2 =              oxy*oxy
```

continued on next page...

Auxiliary variables, continued from previous page

auxiliary for calculating mineralization and nitrification

```
recs =              exp(q10_recs*bottemp) * (theta(oxy)*dn_sed + (1.0-
                    theta(oxy))*dn_sed_anox)
```

using nitrate (and suphalte) to oxidize benthic organic material

```
denitscal =         (1.0-theta(oxy)) * nit/(ksdenit+nit)
```

Under oxic conditions benthic OM is oxidated by oxygen. Under anoxic conditions benthic OM is oxidated by nitrate, if available. Otherwise by sulfate as negative o2

```
ldn_N_sed =         NNdenit * denitscal
```

Under oxic conditions benthic OM is oxidated by oxygen. Under anoxic conditions benthic OM is oxidated by nitrate, if available. Otherwise by sulfate as negative o2

```
ldn_O_sed =         ONamup * (one - denitscal)
```

Phosphate is buried under oxic conditions but no P burial under anoxic conditions

```
one_pburial =       1.0 - theta(oxy) * pfrac * oxy2 * (oxy2 + Kspburial2)
```

nutrient limitation phosphate

```
nutlimc =           phos*phos/(albrfr2+phos*phos)
```

ratio of optimal light for bluegreen

```
ppikb =             min(lightk/min_ocyanol,one)
```

uptake rate of cyano

```
rb =                rb0*min(nutlimc, ppikb*exp(one-ppikb))*four/(four +
                    exp(cyanotll - temp))*(atan(-sali+cyanosul)/pi+half)
```

nutrient limitation phosphate or nitrogen

```
nutlimf =           min(((amm+nit)*(amm+nit))/(alphaf2+(amm+nit)*(amm+nit)),
                    nutlimc)
```

ratio of optimal light for flagellats

```
ppikf =             min(lightk/min_oflagl,one)
```

uptake rate of flag

```
rf =                rf0*min(nutlimf,ppikf*exp(one-ppikf))*flagtsc*exp(flagtll*
                    temp)
```

nutrient limitation phosphate, nitrogen or silicate

```
nutlimd =           min(nutlimf, sil*sil/(alprfs2+sil*sil))
```

ratio of optimal light for diatoms

```
ppikp =             min(lightk/min_odial,one)
```

continued on next page...

Auxiliary variables, continued from previous page

uptake rate of dia

```
rp =                rp0*min(nutlimd, ppikp*exp(one-ppikp))
```

nitrification rate

```
nf =                rnit*oxy/(ksnit + oxy)*exp(anit*temp)
```

More help variables

```
foodmez =           mezprefdia*dia + mezprefflag*flag + mezprefcyano*cyano +
                    mezprefmiz*miz
```

help variable

```
temp2 =             temp * temp
```

mez grazing temperature dependece

```
mezgt =             half + mez_tscale*temp2/(meztk+temp2)
```

food dependent grazing; these have been divided by food; mezfgrazf2 low compared to paper

```
mezgscal =          mezgraz*foodmez/(foodmez*foodmez+mezgrazf*mezgrazf)
```

total mez grazin

```
meztotgraz =        mezgscal*mezgt
```

More help variables

```
foodmiz =           mizprefdia*dia + mizprefflag*flag + mizprefcyano*cyano
```

miz grazing temperature dependece

```
mizgt =             one + temp2/(miztk+temp2)
```

food dependent grazing; these have been divided by food

```
mizgscal =          mizgraz*foodmiz/(foodmiz*foodmiz+mizgrazf*mizgrazf)
```

total miz grazing

```
miztotgraz =        mizgscal*mizgt
```

phytoplankton respiration loss rate (to inorg. compounds)

```
lpn =               nb
```

respiration of nitrate under hypoxic conditions; else = 0.0

```
ldn_N =             zero
```

less hydrogen sulphite formation under hypoxic conditions; else = ONamup

```
ldn_O =             ONamup
```

continued on next page...

Auxiliary variables, continued from previous page

phytoplankton respiration loss rate (to detritus)
`lpd = deltao`

meso zoo plankton loss rates (mortality)
`tldmez = ldmez + mezcl*mez`

micro zoo plankton loss rates (mortality)
`tldmiz = ldmiz`

factor for detritus recycling rates (lds and ldn)
`fac = exp(q10_rec*temp)`

detritus recycling rate (nitrogen, D => Amm)
`ldn = dn*fac`

detritus recycling rate (silicate, Ds => S)
`lds = ds*fac`

total inorganic N inversed and eps
`invdin_eps = one / (nit + amm + eps)`

Constants

Loss rate P to N
`nb = 0.01`

Loss Rate PP to D
`deltao = 0.02`

Loss Rate Detritus to N
`dn = 0.01`

Loss Rate S-Detritus to S
`ds = 0.004`

Half-sat. inhib NO3 denit
`ksdenit = 0.1`

Half-sat. O2 nitrification
`ksnit = 0.01`

Max nitrification rate at T0
`rnit = 0.1`

Max dia uptake rate at T0

continued on next page...

Constants, continued from previous page

rp0 =	1.0

Max Flag uptake rate at T0

rf0 =	0.7

Max cyano uptake rate at T0

rb0 =	0.5

Lower T limit Cyanos

cyanotll =	15.0

Upper S limit Cyanos

cyanosul =	12.0

flag temp scaling

flagtll =	0.06

flag temp dep.

flagtsc =	0.8

background values dia

p0 =	0.001

Background values flag

f0 =	0.001

Background values cyano

b0 =	0.001

Min opt. dia light W/m2

min_odial =	75.0

Min opt. flag light W/m2

min_oflagl =	75.0

Min opt. cyan light W/m2

min_ocyanol =	75.0

Recycling temp dep [/degC]

q10_rec =	0.15

Nitrification temp dep[/degC]

anit =	0.11

continued on next page...

Constants, continued from previous page

Stoechiometric O/N ratio nitr
`ONnitr = 2.0`

Stoechiometric Norg/Nit denit
`NNdenit = 5.3`

Stoech. O/N ratio nitr uptake
`ONniup = 8.625`

Stoech. O/N ratio amm up/rel
`ONamup = 6.625`

Redfield Ratio S/N
`rfs = 0.94`

Redfield Ratio P/N
`rfr = 0.072`

Half-saturation p burial Oxygen dependance
`Kspburial = 0.1`

Fraction of recycled N nitrified in sediment
`fnitr = 0.4`

Loss Rate Sediment to N
`dn_sed = 0.01`

Loss Rate Sed. to N, anoxia
`dn_sed_anox = 0.005`

Recycling temp dep sed. [/C]
`q10_recs = 0.15`

Nnorm/Onorm
`NOR = 0.012`

zero
`zero = 0.0`

one
`one = 1.0`

four
`four = 4.0`

continued on next page...

Constants, continued from previous page

half
`half =` 0.5

dummy
`ldn_N_sed =` 0.0

dummy
`ldn_O_sed =` 0.0

dummy
`one_pburial =` 0.0

dummy
`ldn_N =` 0.0

dummy
`ldn_O =` 0.0

Mesozoopl. grazing constant
`mezgraz =` 0.2

Microzoopl. grazing constant
`mizgraz =` 0.4

Mesozoopl. food dep. constant
`mezgrazf =` 0.4

Microzoopl. food dep. const
`mizgrazf =` 0.2

Microzoopl. grazing temp dep.
`miztk =` 150.0

Mezozoopl. grazing temp dep.
`meztk =` 150.0

Mezozoopl. temp scaling
`mez_tscale =` 2.0

Mesozoopl. closure
`mezcl =` 0.02

Mesozoopl. mortality

continued on next page...

Constants, continued from previous page	
ldmez =	0.02
Micrezoopl. mortality	
ldmiz =	0.05
Mesozoopl. excretion	
lnmez =	0.45
Microzoopl. excretion	
lnmiz =	0.3
Preference of mezoo on dia	
mezprefdia =	1.0
Preference of mezoo on flag	
mezprefflag =	0.3
Preference of mezoo on cyano	
mezprefcyano =	0.3
Preference of mezoo on mizoo	
mezprefmiz =	1.0
Preference of mizoo on dia	
mizprefdia =	0.3
Preference of mizoo on flag	
mizprefflag =	1.0
Preference of mizoo on cyano	
mizprefcyano =	0.3
Fraction of produced lDON	
ldon_frac =	0.1
lDON turning over rate [1/d]	
ldon_tor =	0.03
Process limitation factors	

4 Tracer equations

Tracer equations	
Change of: ammonium	
$\frac{d}{dt}$ amm =	
+ mineralization_nitr_sed/(cgt_cgt_density)	mineralization of bentic nitrogen, mmol cN/m2/d
+ (respiration_miz)*((one-ldon_frac))	respiration of micro-zooplankton
+ (respiration_mez)*((one-ldon_frac))	respiration of meso-zooplankton
+ (respiration_dia)*((one-ldon_frac))	respiration of diatoms
+ (respiration_flag)*((one-ldon_frac))	respiration of flagelattes
+ (respiration_cyano)*((one-ldon_frac))	respiration of cyano bacteria
+ recycling_detritus_to_n	recycling of detritus
+ degradation_ldon	degradation of lDON
- nitrification_amm_sed/(cgt_celcgt_density)	nitrification
- uptake_amm_by_dia	uptake of ammonium (, phosphate and silicate) by diatoms
- uptake_amm_by_flag	uptake of ammonium (and phosphate) by flagellates
- nitrification	nitrification

continued on next page...

Tracer equations, continued from previous page

Change of: nitrate

$\frac{d}{dt}$ nit =

+ nitrification	nitrification
- (mineralization_nitr_sed)*(ldn_N_sed)/(cgt_cellheight*cgt_density)	mineralization of bentic nitrogen, mmol N/m2/d
- uptake_nit_by_dia	uptake of nitrate (, phosphate and silicate) by diatoms
- uptake_nit_by_flat	uptake of nitrate (and phosphate) by flagellates
- (recycling_detritus_to_n)*(ldn_N)	recycling of detritus

Change of: phosphate

$\frac{d}{dt}$ phos =

+ (mineralization_nitr_sed)*(rfr*one_pburial)/(cgt_cellheight*cgt_density)	mineralization of bentic nitrogen, mmol N/m2/d
+ (respiration_miz)*(rfr)	respiration of micro-zooplankton
+ (respiration_mez)*(rfr)	respiration of meso-zooplankton
+ (respiration_dia)*(rfr)	respiration of diatoms
+ (respiration_flag)*(rfr)	respiration of flagelattes
+ (respiration_cyano)*(rfr)	respiration of cyano bacteria
+ (recycling_detritus_to_n)*(rfr)	recycling of detritus
- (uptake_amm_by_dia)*(rfr)	uptake of ammonium (, phosphate and silicate) by diatoms
- (uptake_nit_by_dia)*(rfr)	uptake of nitrate (, phosphate and silicate) by diatoms
- (uptake_amm_by_flag)*(rfr)	uptake of ammonium (and phosphate) by flagellates

continued on next page...

Tracer equations, continued from previous page

`- (uptake_nit_by_flat)*(rfr)`	uptake of nitrate (and phosphate) by flagellates
`- (uptake_phos_by_cyano)*(rfr)`	uptake of phosphate by cyano bacteria

Change of: silicate

$\frac{d}{dt}$ `sil` =

`+ (respiration_dia)*(rfs)`	respiration of diatoms
`+ recycling_detritus_to_sil`	recycling of detritus
`- (uptake_amm_by_dia)*(rfs)`	uptake of ammonium (, phosphate and silicate) by diatoms
`- (uptake_nit_by_dia)*(rfs)`	uptake of nitrate (, phosphate and silicate) by diatoms

Change of: diatoms

$\frac{d}{dt}$ `dia` =

`+ uptake_amm_by_dia`	uptake of ammonium (, phosphate and silicate) by diatoms
`+ uptake_nit_by_dia`	uptake of nitrate (, phosphate and silicate) by diatoms
`- grazing_miz_on_dia`	Grazing of micro-zooplankton on diatoms
`- grazing_mez_on_dia`	Grazing of meso-zooplankton on diatoms
`- respiration_dia`	respiration of diatoms
`- mortality_dia`	mortality of diatoms

Change of: flagellates

$\frac{d}{dt}$ `flag` =

`+ uptake_amm_by_flag`	uptake of ammonium (and phosphate) by flagellates
`+ uptake_nit_by_flat`	uptake of nitrate (and phosphate) by flagellates

continued on next page...

Tracer equations, continued from previous page	
- grazing_miz_on_flag	Grazing of micro-zooplankton on flaggelates
- grazing_mez_on_flag	Grazing of meso-zooplankton on flaggelates
- respiration_flag	respiration of flagelattes
- mortality_flag	mortality of flagellates

Change of: cyano bacteria

$\frac{d}{dt}$ cyano =

+ uptake_phos_by_cyano	uptake of phosphate by cyano bacteria
- grazing_miz_on_cyano	Grazing of micro-zooplankton on cyano
- grazing_mez_on_cyano	Grazing of meso-zooplankton on cyano
- respiration_cyano	respiration of cyano bacteria
- mortality_cyano	mortality of cyano bacteria

Change of: meso zooplankton

$\frac{d}{dt}$ mez =

+ grazing_mez_on_dia	Grazing of meso-zooplankton on diatoms
+ grazing_mez_on_flag	Grazing of meso-zooplankton on flaggelates
+ grazing_mez_on_cyano	Grazing of meso-zooplankton on cyano
+ grazing_mez_on_miz	Grazing of meso-zooplankton on micro-zooplankton
- respiration_mez	respiration of meso-zooplankton
- mortality_mez	mortality of meso-zooplankton

Change of: micro zooplakton

$\frac{d}{dt}$ miz =

+ grazing_miz_on_dia	Grazing of micro-zooplankton on diatoms
+ grazing_miz_on_flag	Grazing of micro-zooplankton on flaggelates

continued on next page...

Tracer equations, continued from previous page

+ grazing_miz_on_cyano	Grazing of micro-zooplankton on cyano
- respiration_miz	respiration of micro-zooplankton
- mortality_miz	mortality of micro-zooplankton
- grazing_mez_on_miz	Grazing of meso-zooplankton on micro-zooplankton

Change of: Detritus

$\frac{d}{dt}$ det =

+ mortality_miz	mortality of micro-zooplankton
+ mortality_mez	mortality of meso-zooplankton
+ mortality_dia	mortality of diatoms
+ mortality_flag	mortality of flagellates
+ mortality_cyano	mortality of cyano bacteria
- recycling_detritus_to_n	recycling of detritus

Change of: S-Detritus

$\frac{d}{dt}$ dets =

+ (grazing_miz_on_dia)*(rfs)	Grazing of micro-zooplankton on diatoms
+ (grazing_mez_on_dia)*(rfs)	Grazing of meso-zooplankton on diatoms
+ (mortality_dia)*(rfs)	mortality of diatoms
- recycling_detritus_to_sil	recycling of detritus

Change of: ldon is the labile DON fraction

$\frac{d}{dt}$ ldon =

+ (respiration_miz)* (ldon_frac)	respiration of micro-zooplankton
+ (respiration_mez)* (ldon_frac)	respiration of meso-zooplankton

continued on next page...

Tracer equations, continued from previous page

`+ (respiration_dia)* (ldon_frac)`	respiration of diatoms
`+ (respiration_flag)* (ldon_frac)`	respiration of flagelattes
`+ (respiration_cyano)* (ldon_frac)`	respiration of cyano bacteria
`- degradation_ldon`	degradation of lDON

Change of: Oxygen

$\frac{d}{dt}$ `oxy` =

`+ (uptake_amm_by_dia)*(NOR* ONamup)`	uptake of ammonium (, phosphate and silicate) by diatoms
`+ (uptake_nit_by_dia)*(NOR* ONniup)`	uptake of nitrate (, phosphate and silicate) by diatoms
`+ (uptake_amm_by_flag)*(NOR* ONamup)`	uptake of ammonium (and phosphate) by flagellates
`+ (uptake_nit_by_flat)*(NOR* ONniup)`	uptake of nitrate (and phosphate) by flagellates
`+ (uptake_phos_by_cyano)* (NOR*ONamup)`	uptake of phosphate by cyano bacteria
`- (nitrification_amm_sed)* (ONnitr*NOR)/(cgt_cellheight* cgt_density)`	nitrification
`- (mineralization_nitr_sed)* (NOR*ldn_O_sed) /(cgt_cellheight*cgt_density)`	mineralization of bentic nitrogen, mmol N/m2/d
`- (respiration_miz)*(NOR* ONamup)`	respiration of micro-zooplankton
`- (respiration_mez)*(NOR* ONamup)`	respiration of meso-zooplankton
`- (respiration_dia)*(NOR* ONamup)`	respiration of diatoms

continued on next page...

Tracer equations, continued from previous page

`- (respiration_flag)*(NOR* ONamup)`	respiration of flagelattes
`- (respiration_cyano)*(NOR* ONamup)`	respiration of cyano bacteria
`- (recycling_detritus_to_n)* (NOR*ldn_O)`	recycling of detritus
`- (nitrification)*(NOR* ONnitr)`	nitrification

Change of: nitrogen in the sediment

$\frac{d}{dt}$ `nitr` =

`- mineralization_nitr_sed`	mineralization of bentic nitrogen, mmol N/m2/d

Change of: silicate in the sediment

$\frac{d}{dt}$ `sili` =

`- mineralization_sili_sed`	mineralization of bentic silicate, mmol N/m2/d

Change of: reduced nitrogen

$\frac{d}{dt}$ `nred` =

Change of: oxidized nitrogen

$\frac{d}{dt}$ `nox` =

Change of: oxidized phosphorus (phosphate)

$\frac{d}{dt}$ `pox` =

Change of: ammonium; containing

$\frac{d}{dt}$ `amm_with_ship_N` =

`+ mineralization_nitr_sed_ship_N cgt_density)`	mineralization of bentic nitrogen, mmol N/m2/d; sub-process for ship nitrogen
`+ (respiration_miz_ship_N)* ((one-ldon_frac))`	respiration of micro-zooplankton; sub-process for ship nitrogen
`+ (respiration_mez_ship_N)* ((one-ldon_frac))`	respiration of meso-zooplankton; sub-process for ship nitrogen

continued on next page...

Tracer equations, continued from previous page

`+ (respiration_dia_ship_N)* ((one-ldon_frac))`	respiration of diatoms; sub-process for ship nitrogen
`+ (respiration_flag_ship_N)* ((one-ldon_frac))`	respiration of flagelattes; sub-process for ship nitrogen
`+ (respiration_cyano_ship_N)* ((one-ldon_frac))`	respiration of cyano bacteria; sub-process for ship nitrogen
`+ recycling_detritus_to_n_ship_N`	recycling of detritus; sub-process for ship nitrogen
`+ degradation_ldon_ship_N`	degradation of lDON; sub-process for ship nitrogen
`- nitrification_amm_sed/(cgt_cel cgt_density)* max(0.0,min(1.0,amm_with_ship_ ))`	nitrification
`- uptake_amm_by_dia* max(0.0,min(1.0,amm_with_ship_ ))`	uptake of ammonium (, phosphate and silicate) by diatoms
`- uptake_amm_by_flag* max(0.0,min(1.0,amm_with_ship_ ))`	uptake of ammonium (and phosphate) by flagellates
`- nitrification* max(0.0,min(1.0,amm_with_ship_ ))`	nitrification

Change of: nitrate; containing

$\frac{d}{dt}$ `nit_with_ship_N` =

`+ nitrification_ship_N`	nitrification; sub-process for ship nitrogen
`- (mineralization_nitr_sed)* (ldn_N_sed)/(cgt_cellheight* cgt_density)* max(0.0,min(1.0,nit_with_ship_ ))`	mineralization of bentic nitrogen, mmol N/m2/d

continued on next page...

Tracer equations, continued from previous page

- uptake_nit_by_dia* max(0.0,min(1.0,nit_with_ship_))	uptake of nitrate (, phosphate and silicate) by diatoms
- uptake_nit_by_flat* max(0.0,min(1.0,nit_with_ship_))	uptake of nitrate (and phosphate) by flagellates
- (recycling_detritus_to_n)* (ldn_N)* max(0.0,min(1.0,nit_with_ship_))	recycling of detritus

Change of: diatoms; containing

$\frac{d}{dt}$ dia_with_ship_N =

+ uptake_amm_by_dia_ship_N	uptake of ammonium (, phosphate and silicate) by diatoms; sub-process for ship nitrogen
+ uptake_nit_by_dia_ship_N	uptake of nitrate (, phosphate and silicate) by diatoms; sub-process for ship nitrogen
- grazing_miz_on_dia* max(0.0,min(1.0,dia_with_ship_))	Grazing of micro-zooplankton on diatoms
- grazing_mez_on_dia* max(0.0,min(1.0,dia_with_ship_))	Grazing of meso-zooplankton on diatoms
- respiration_dia* max(0.0,min(1.0,dia_with_ship_))	respiration of diatoms
- mortality_dia* max(0.0,min(1.0,dia_with_ship_))	mortality of diatoms

Change of: flagellates; containing

$\frac{d}{dt}$ flag_with_ship_N =

+ uptake_amm_by_flag_ship_N	uptake of ammonium (and phosphate) by flagellates; sub-process for ship nitrogen

continued on next page...

Tracer equations, continued from previous page

+ uptake_nit_by_flat_ship_N	uptake of nitrate (and phosphate) by flagellates; sub-process for ship nitrogen
- grazing_miz_on_flag* max(0.0,min(1.0,flag_with_ship))	Grazing of micro-zooplankton on flaggelates
- grazing_mez_on_flag* max(0.0,min(1.0,flag_with_ship))	Grazing of meso-zooplankton on flaggelates
- respiration_flag* max(0.0,min(1.0,flag_with_ship))	respiration of flagelattes
- mortality_flag* max(0.0,min(1.0,flag_with_ship))	mortality of flagellates

Change of: cyano bacteria; containing

$\frac{d}{dt}$ cyano_with_ship_N =

- grazing_miz_on_cyano* max(0.0,min(1.0,cyano_with_shi))	Grazing of micro-zooplankton on cyano
- grazing_mez_on_cyano* max(0.0,min(1.0,cyano_with_shi))	Grazing of meso-zooplankton on cyano
- respiration_cyano* max(0.0,min(1.0,cyano_with_shi))	respiration of cyano bacteria
- mortality_cyano* max(0.0,min(1.0,cyano_with_shi))	mortality of cyano bacteria

Change of: meso zooplankton; containing

$\frac{d}{dt}$ mez_with_ship_N =

+ grazing_mez_on_dia_ship_N	Grazing of meso-zooplankton on diatoms; sub-process for ship nitrogen

continued on next page...

Tracer equations, continued from previous page

+ grazing_mez_on_flag_ship_N	Grazing of meso-zooplankton on flaggelates; sub-process for ship nitrogen
+ grazing_mez_on_cyano_ship_N	Grazing of meso-zooplankton on cyano; sub-process for ship nitrogen
+ grazing_mez_on_miz_ship_N	Grazing of meso-zooplankton on micro-zooplankton; sub-process for ship nitrogen
- respiration_mez* max(0.0,min(1.0,mez_with_ship_))	respiration of meso-zooplankton
- mortality_mez* max(0.0,min(1.0,mez_with_ship_))	mortality of meso-zooplankton

Change of: micro zooplakton; containing

$\frac{d}{dt}$ miz_with_ship_N =

+ grazing_miz_on_dia_ship_N	Grazing of micro-zooplankton on diatoms; sub-process for ship nitrogen
+ grazing_miz_on_flag_ship_N	Grazing of micro-zooplankton on flaggelates; sub-process for ship nitrogen
+ grazing_miz_on_cyano_ship_N	Grazing of micro-zooplankton on cyano; sub-process for ship nitrogen
- respiration_miz* max(0.0,min(1.0,miz_with_ship_))	respiration of micro-zooplankton
- mortality_miz* max(0.0,min(1.0,miz_with_ship_))	mortality of micro-zooplankton
- grazing_mez_on_miz* max(0.0,min(1.0,miz_with_ship_))	Grazing of meso-zooplankton on micro-zooplankton

Change of: Detritus; containing

$\frac{d}{dt}$ det_with_ship_N =

continued on next page...

Tracer equations, continued from previous page

+ mortality_miz_ship_N	mortality of micro-zooplankton; sub-process for ship nitrogen
+ mortality_mez_ship_N	mortality of meso-zooplankton; sub-process for ship nitrogen
+ mortality_dia_ship_N	mortality of diatoms; sub-process for ship nitrogen
+ mortality_flag_ship_N	mortality of flagellates; sub-process for ship nitrogen
+ mortality_cyano_ship_N	mortality of cyano bacteria; sub-process for ship nitrogen
- recycling_detritus_to_n* max(0.0,min(1.0,det_with_ship_))	recycling of detritus

Change of: ldon is the labile DON fraction; containing

$\frac{d}{dt}$ ldon_with_ship_N =

+ (respiration_miz_ship_N)* (ldon_frac)	respiration of micro-zooplankton; sub-process for ship nitrogen
+ (respiration_mez_ship_N)* (ldon_frac)	respiration of meso-zooplankton; sub-process for ship nitrogen
+ (respiration_dia_ship_N)* (ldon_frac)	respiration of diatoms; sub-process for ship nitrogen
+ (respiration_flag_ship_N)* (ldon_frac)	respiration of flagelattes; sub-process for ship nitrogen
+ (respiration_cyano_ship_N)* (ldon_frac)	respiration of cyano bacteria; sub-process for ship nitrogen
- degradation_ldon* max(0.0,min(1.0,ldon_with_ship))	degradation of lDON

Change of: nitrogen in the sediment; containing

$\frac{d}{dt}$ nitr_with_ship_N =

- mineralization_nitr_sed* max(0.0,min(1.0,nitr_with_ship))	mineralization of bentic nitrogen, mmol N/m2/d

continued on next page...

Tracer equations, continued from previous page

Change of: reduced nitrogen; containing

$\frac{d}{dt}$ `nred_with_ship_N` =

Change of: oxidized nitrogen; containing

$\frac{d}{dt}$ `nox_with_ship_N` =

Change of: ammonium; containing

$\frac{d}{dt}$ `amm_with_river_N` =

`+ mineralization_nitr_sed_river_cgt_density)`	mineralization of bentic nitrogen, mmol N/m2/d; sub-process for river nitrogen
`+ (respiration_miz_river_N)* ((one-ldon_frac))`	respiration of micro-zooplankton; sub-process for river nitrogen
`+ (respiration_mez_river_N)* ((one-ldon_frac))`	respiration of meso-zooplankton; sub-process for river nitrogen
`+ (respiration_dia_river_N)* ((one-ldon_frac))`	respiration of diatoms; sub-process for river nitrogen
`+ (respiration_flag_river_N)* ((one-ldon_frac))`	respiration of flagelattes; sub-process for river nitrogen
`+ (respiration_cyano_river_N) *((one-ldon_frac))`	respiration of cyano bacteria; sub-process for river nitrogen
`+ recycling_detritus_to_n_river_`	recycling of detritus; sub-process for river nitrogen
`+ degradation_ldon_river_N`	degradation of lDON; sub-process for river nitrogen
`- nitrification_amm_sed/(cgt_cel cgt_density)* max(0.0,min(1.0,amm_with_river ))`	nitrification
`- uptake_amm_by_dia* max(0.0,min(1.0,amm_with_river ))`	uptake of ammonium (, phosphate and silicate) by diatoms

continued on next page...

Tracer equations, continued from previous page

- uptake_amm_by_flag* max(0.0,min(1.0,amm_with_river))	uptake of ammonium (and phosphate) by flagellates
- nitrification* max(0.0,min(1.0,amm_with_river))	nitrification

Change of: nitrate; containing

$\frac{d}{dt}$ nit_with_river_N =

+ nitrification_river_N	nitrification; sub-process for river nitrogen
- (mineralization_nitr_sed)* (ldn_N_sed)/(cgt_cellheight* cgt_density)* max(0.0,min(1.0,nit_with_river))	mineralization of bentic nitrogen, mmol N/m2/d
- uptake_nit_by_dia* max(0.0,min(1.0,nit_with_river))	uptake of nitrate (, phosphate and silicate) by diatoms
- uptake_nit_by_flat* max(0.0,min(1.0,nit_with_river))	uptake of nitrate (and phosphate) by flagellates
- (recycling_detritus_to_n)* (ldn_N)* max(0.0,min(1.0,nit_with_river))	recycling of detritus

Change of: diatoms; containing

$\frac{d}{dt}$ dia_with_river_N =

+ uptake_amm_by_dia_river_N	uptake of ammonium (, phosphate and silicate) by diatoms; sub-process for river nitrogen
+ uptake_nit_by_dia_river_N	uptake of nitrate (, phosphate and silicate) by diatoms; sub-process for river nitrogen
- grazing_miz_on_dia* max(0.0,min(1.0,dia_with_river))	Grazing of micro-zooplankton on diatoms

continued on next page...

Tracer equations, continued from previous page

- grazing_mez_on_dia* max(0.0,min(1.0,dia_with_river	Grazing of meso-zooplankton on diatoms
- respiration_dia* max(0.0,min(1.0,dia_with_river	respiration of diatoms
- mortality_dia* max(0.0,min(1.0,dia_with_river	mortality of diatoms

Change of: flagellates; containing

$\frac{d}{dt}$ flag_with_river_N =

+ uptake_amm_by_flag_river_N	uptake of ammonium (and phosphate) by flagellates; sub-process for river nitrogen
+ uptake_nit_by_flat_river_N	uptake of nitrate (and phosphate) by flagellates; sub-process for river nitrogen
- grazing_miz_on_flag* max(0.0,min(1.0,flag_with_rive	Grazing of micro-zooplankton on flaggelates
- grazing_mez_on_flag* max(0.0,min(1.0,flag_with_rive	Grazing of meso-zooplankton on flaggelates
- respiration_flag* max(0.0,min(1.0,flag_with_rive	respiration of flagelattes
- mortality_flag* max(0.0,min(1.0,flag_with_rive	mortality of flagellates

Change of: cyano bacteria; containing

$\frac{d}{dt}$ cyano_with_river_N =

- grazing_miz_on_cyano* max(0.0,min(1.0,cyano_with_riv	Grazing of micro-zooplankton on cyano

continued on next page...

Tracer equations, continued from previous page

- grazing_mez_on_cyano* max(0.0,min(1.0,cyano_with_riv))	Grazing of meso-zooplankton on cyano
- respiration_cyano* max(0.0,min(1.0,cyano_with_riv))	respiration of cyano bacteria
- mortality_cyano* max(0.0,min(1.0,cyano_with_riv))	mortality of cyano bacteria

Change of: meso zooplankton; containing

$\frac{d}{dt}$ mez_with_river_N =

+ grazing_mez_on_dia_river_N	Grazing of meso-zooplankton on diatoms; sub-process for river nitrogen
+ grazing_mez_on_flag_river_N	Grazing of meso-zooplankton on flaggelates; sub-process for river nitrogen
+ grazing_mez_on_cyano_river_N	Grazing of meso-zooplankton on cyano; sub-process for river nitrogen
+ grazing_mez_on_miz_river_N	Grazing of meso-zooplankton on micro-zooplankton; sub-process for river nitrogen
- respiration_mez* max(0.0,min(1.0,mez_with_river))	respiration of meso-zooplankton
- mortality_mez* max(0.0,min(1.0,mez_with_river))	mortality of meso-zooplankton

Change of: micro zooplakton; containing

$\frac{d}{dt}$ miz_with_river_N =

+ grazing_miz_on_dia_river_N	Grazing of micro-zooplankton on diatoms; sub-process for river nitrogen
+ grazing_miz_on_flag_river_N	Grazing of micro-zooplankton on flaggelates; sub-process for river nitrogen

continued on next page...

Tracer equations, continued from previous page

+ grazing_miz_on_cyano_river_N	Grazing of micro-zooplankton on cyano; sub-process for river nitrogen
- respiration_miz* max(0.0,min(1.0,miz_with_river))	respiration of micro-zooplankton
- mortality_miz* max(0.0,min(1.0,miz_with_river))	mortality of micro-zooplankton
- grazing_mez_on_miz* max(0.0,min(1.0,miz_with_river))	Grazing of meso-zooplankton on micro-zooplankton

Change of: Detritus; containing

$\frac{d}{dt}$ det_with_river_N =

+ mortality_miz_river_N	mortality of micro-zooplankton; sub-process for river nitrogen
+ mortality_mez_river_N	mortality of meso-zooplankton; sub-process for river nitrogen
+ mortality_dia_river_N	mortality of diatoms; sub-process for river nitrogen
+ mortality_flag_river_N	mortality of flagellates; sub-process for river nitrogen
+ mortality_cyano_river_N	mortality of cyano bacteria; sub-process for river nitrogen
- recycling_detritus_to_n* max(0.0,min(1.0,det_with_river))	recycling of detritus

Change of: ldon is the labile DON fraction; containing

$\frac{d}{dt}$ ldon_with_river_N =

+ (respiration_miz_river_N)* (ldon_frac)	respiration of micro-zooplankton; sub-process for river nitrogen
+ (respiration_mez_river_N)* (ldon_frac)	respiration of meso-zooplankton; sub-process for river nitrogen

continued on next page...

Tracer equations, continued from previous page

`+ (respiration_dia_river_N)* (ldon_frac)`	respiration of diatoms; sub-process for river nitrogen
`+ (respiration_flag_river_N)* (ldon_frac)`	respiration of flagelattes; sub-process for river nitrogen
`+ (respiration_cyano_river_N) *(ldon_frac)`	respiration of cyano bacteria; sub-process for river nitrogen
`- degradation_ldon* max(0.0,min(1.0,ldon_with_rive ))`	degradation of lDON

Change of: nitrogen in the sediment; containing

$\frac{d}{dt}$ `nitr_with_river_N` =

`- mineralization_nitr_sed* max(0.0,min(1.0,nitr_with_rive ))`	mineralization of bentic nitrogen, mmol N/m2/d

Change of: reduced nitrogen; containing

$\frac{d}{dt}$ `nred_with_river_N` =

Change of: oxidized nitrogen; containing

$\frac{d}{dt}$ `nox_with_river_N` =