Constant model parameters

$ANSFMIN = 0.01$	minimal value of $ansf$ (release of inorganic nitrogen from sediment) at 0 °C ($g\ N\ m^{-2}\ d^{-1}$)
$APSFMAX = 7$	maximal value of $apsf$ (phosphorus release from sediment), if oxygen concentration $o < LINDEN$ ($mg\ P\ m^{-2}\ d^{-1}$)
$APSFMIN = 1$	minimal value of $apsf$ (phosphorus release from sediment), at saturation concentration of oxygen ($mg\ P\ m^{-2}\ d^{-1}$)
$AZMAX = 0.8$	maximal assimilation coefficient of zooplankton at very low ingestion rate (-)
$AZMIN = 0.4$	minimal assimilation coefficient at ($g = GMAX$) (-s)
$DTA = 3.9$	parameters of the empirical relationship between egg development time of crustaceans and temperature (-)
$DTB = 0.15$	cf. DTA
$DTC = 0.26$	cf. DTA
$DTMIN = 5$	minimum value of egg development time of the crustaceans below of which the egg development time is neglected in the calculation of zooplankton growth (d)
$EPSD = 0.023$	specific light extinction coefficient of detritus ($m^2\ g^{-1}$)
$GI = 0.8$	inhibition factor of the ingestion rate due to light (-)
$GMAX = 1.3$	maximum value of g (specific ingestion rate of zooplankton) ($g\ g^{-1}\ d^{-1}$)
$GMIN = 0.26$	minimum value of g (specific ingestion rate of zooplankton) near 0 °C ($g\ g^{-1}\ d^{-1}$)
$KANSF = 0.004$	slope of the function $ansf(temp)$ (release of organic nitrogen from sediment) ($g\ m^{-2}\ d^{-1}\ °C^{-1}$)
$KAPSF = 1.25$	half saturation constant of the inverse function $apsf(o)$ (phosphorus release from sediment) ($g\ O_2\ m^{-3}$)
$KDEN = 0.045$	parameter of the dependence of denitrification on the supply of organic matter ($g\ cm^{-3}$)
$KMINER = 0.04$	mineralisation constant related to oxygen consumption by sinking phytoplankton (d^{-1})
$KMO = 0.35$	half saturation constant of the dependence of zooplankton mortality on zooplankton biomass ($g\ m^{-3}$)
$KPSED = 0$	specific scenario parameter for hard water lakes, sedimentation of phosphate by co-precipitation with calcite as daily percentage of the in-lake phosphate (-)
$KSEZA = 2.5$	oxygen concentration o, which causes 50% of the maximal oxygen consumption by the sediment ($g\ O_2\ m^{-3}$)

$KSRFMAX = 4.3$	critical value of $ksrf$ (corrected strong rain factor), above the underwater light climate is reduced due to erosion-induced turbidity (-)
$KXG = 5$	half saturation constant of the relationship between ingestion rate of zooplankton and food ($g\ m^{-3}$)
$KXMIN = 2.5$	theoretical minimum of kx and kxn (half saturation constant of the inverse relationship between photosynthesis rate and biomass of phytoplankton at nitrogen limitation of phytoplankton growth) ($g\ m^{-3}$)
$KZMIN = 4$	theoretical minimum value of kz (half saturation value of the inverse relationship between ingestion rate and biomass of zooplankton) ($g\ m^{-3}$)
$LGH = 0.4$	parameter of the dependence of the half saturation value kz_i on phytoplankton biomass at high biomass of x_i (-)
$LGL = 5.76$	parameter of the dependence of the half saturation value kz_i on phytoplankton biomass at low biomass of x_i (-)
$LINDEN = 1$	oxygen threshold below which denitrification occurs ($g\ O_2$ m^{-3})
$LXH = 0.1$	parameter of the dependence of the half saturation value kx on the phosphate concentration at high phosphate concentration (-)
$LXHN = 209.56$	parameter of the dependence of the half saturation value kxn on the concentration of inorganic nitrogen at high inorganic nitrogen concentration (-)
$LXL = 2.78$	parameter of the dependence of the half saturation value kx on on the phosphate concentration at low phosphate concentration(-)
$LXLN = 19.04$	parameter of the dependence of the half saturation value kxn on the concentration of inorganic nitrogen at low inorganic nitrogen concentration (-)
$MGH = 1.5$	parameter of the dependence of the half saturation value kz on phytoplankton biomass at high biomass of phytoplankton (-)
$MGL = 0.41$	parameter of the dependence of the half saturation value kz on phytoplankton biomass at low biomass of phytoplankton (-)
$MOMIN = 0.015$	rate of zooplankton mortality near 0 °C at zooplankton biomass z much higher than KMO (d^{-1})
$MOT = 0.006$	slope of the function $mortz(temp)$ ($°C\ d^{-1}$)
$MXH = 1.55$	parameter of the dependence of the half saturation value kx on the phosphate concentration at high phosphate concentration (-)

$MXL = 0.39$	parameter of the dependence of the half saturation value kx on the phosphate concentration at low phosphate concentration (-)
$OPTNP = 0.0072$	optimum N/P mass ratio (-)
$PF = 1$	preference factor for ingestion of detritus by zooplankton (-)
$R = 2$	parameter of the dependence of the ingestion rate of zooplankton on water temperature (-)
$RAT = 0.7$	ratio of soluble to total phosphorus in zooplankton faeces (-)
$RATF = 0.7$	ratio of soluble to total phosphorus in fish excrements and during remineralization of dead zooplankton (-)
$RATN = 0.7$	ratio of soluble to total nitrogen in zooplankton faeces (-)
$RATNF = 0.7$	ratio of soluble to total nitrogen in fish excrements and during remineralization of dead zooplankton (-)
$RL = 0.9$	factor for light reflection at the water surface (-)
$RLW = 0.2$	factor for light reflection at the water during winter stagnation (ice cover) (-)
$RXMF = 0.3$	fraction of the gross photosynthesis rate which is consumed by respiration additionally to the basis respiration (-)
$RZMIN = 0.08$	respiration rate of zooplankton at optimal temperature for feeding but without food supply (d^{-1})
$RZOPT = 0.22$	respiration rate of zooplankton at optimal temperature for feeding and maximum ingestion rate (d^{-1})
$RZTMIN = 0.05$	respiration rate of zooplankton near O °C and optimal food supply (d^{-1})
$EPSR = 0.2668$	specific light extinction coefficient due to turbidity and erosion at strong rain events ($m^2\ g^{-1}$)
$TOPTZ = 20$	optimal temperature for feeding activity of the zooplankton ($^{\circ}C$)
$UXZD = 0.75$	factor of the physiological utilisation of detritus by zooplankton (-)
$VD = 0.2$	net sinking velocity of detritus ($m\ d^{-1}$)
$VMIG = 0.15$	net migration velocity of zooplankton from hypolimnion to epilimnion ($m\ d^{-1}$)
$WPKX = 12.5$	point of inflexion of the function $kx(p)$ ($mg\ m^{-3}$)
$WPKZ = 8.6$	point of inflexion of the function $kz(x)$ ($g\ m^{-3}$)
$YD = 2$	phosphorus related 'yield' coefficient of detritus (g wet weight/$mg\ P$)
$YND = 285$	nitrogen related 'yield' coefficient of detritus (g wet weight/$g\ N$)
$YNX = 57$	nitrogen related yield coefficient of phytoplankton (g wet weight $/g\ N$)

$YOX = 3.75$	oxygen equivalent of the biomass (g wet weight/g O_2)
$YZN = 110$	nitrogen related yield coefficient of zooplankton (g wet weight/g N)
$YZP = 0.8$	phosphorus related yield coefficient of phytoplankton (g wet weight/mg P)
$EPSX = (0.0368, 0.046, 0.046)$	specific light extinction coefficient of phytoplankton group i (m^2 g^{-1})
$KI = (28, 29, 29)$	half saturation constant of the dependence of the photosynthesis rate of phytoplankton group i on light (J cm^{-2} d^{-1})
$KN = (0.0123, 0.0123, 0.0095)$	half saturation constant of the dependence of the photosynthesis rate of phytoplankton group i on nitrogen at minimal phytoplankton biomass (g N m^{-3})
$KP = (1.7, 1.7, 9.5)$	half saturation constant of the dependence of the photosynthesis rate of phytoplankton group i on phosphorus at minimal phytoplankton biomass (g N m^{-3})
$KPF = (1.1, 4, 0)$	half saturation value of the dependence of the preference factor of zooplankton pf_i for phytoplankton group i on availability of the other groups (g m^{-3})
$PFC = (0, 0.3, 1)$	preference factor for ingestion of phytoplankton by zooplankton (-)
$PFX = (0.1, 3, 0)$	threshold of the other phytoplankton groups above which pf_i is decreasing (g m^{-3})
$PHOTXMAX = (1.7, 1.8, 3.5)$	maximum value of $photx_i$ (gross photosynthesis rate of group i) at optimal conditions (d^{-1})
$PHOTXMIN = (0, 0.17, 0.35)$	values of $photx_i$ near to 0 °C at optimal light and nutrient conditions (d^{-1})
$RXTMIN = (0, 0.02, 0.02)$	rate of basis respiration of phytoplankton group i near 0 °C (d^{-1})
$RXTOPT = (0.057, 0.06, 0.06)$	rate of basis respiration of phytoplankton group i at the group specific optimum temperature (d^{-1})
$TOPTX = (25, 20, 25)$	optimum temperature for phytoplankton group i (°C)
$UXZ = (1, 1, 1)$	factor of the physiological utilisation of phytoplankton group i by zooplankton (-)
$VS = (0.05, 0.1, 0.1)$	net sinking velocity of phytoplankton group i (m d^{-1})
$YX = (1, 0.8, 0.41)$	phosphorus related yield coefficient of phytoplankton group i (g wet weight / mg P)

Internal variables of the model

$ansf$	release rate of anorganic nitrogen from sediment ($g\ N\ m^{-2}\ d^{-1}$)
$apsf$	release rate of anorganic phosphorus from sediment ($mg\ P\ m^{-2}\ d^{-1}$)
$assiz$	assimilation rate of zooplankton ($g\ g^{-1}\ d^{-1}$)
az	assimilation coefficient (g food assimilated / g food ingested)
bd	sedimentation rate of detritus (d^{-1})
bx_i	sedimentation rate of phytoplankton group i (d^{-1})
$dgraz$	loss of detritus by zooplankton grazing ($g\ m^{-3}\ d^{-1}$)
dt	egg development time of all crustaceans (d)
egg	reduction factor of the zooplankton growth rate due to low reproduction (-)
eps	extinction coefficient of light (photosynthetic active radiation between 400 and 700 nm) (m^{-1})
g	specific ingestion rate of zooplankton ($g\ g^{-1}\ d^{-1}$)
g_i	specific ingestion rate of phytoplankton group i by zooplankton ($g\ g^{-1}\ d^{-1}$)
$g3d$	specific ingestion rate of detritus by zooplankton ($g\ g^{-1}\ d^{-1}$)
gdb	term of the dependence of the ingestion rate in the dark on the biomass of the phyto- and zooplankton (-)
gdt	temperature term of the ingestion rate in the dark ($g\ g^{-1}\ d^{-1}$)
gl	specific ingestion rate of zooplankton g in the light ($g\ g^{-1}\ d^{-1}$)
hl	light hours per day (photo period) ($h\ d^{-1}$)
hwg_i	auxillary value for the calculation of the ingestion rate g_i ($g\ g^{-1}\ d^{-1}$)
$hwgd$	auxillary value for the calculation of gd ($g\ g^{-1}\ d^{-1}$)
$hwgd_i$	auxillary value for the calculation of gd ($g\ g^{-1}\ d^{-1}$)
$hwgdb_i$	auxillary value for the calculation of gdb (-)
$hwgdbd$	auxillary value for the calculation of gdb (-)
$hwgdd$	auxillary value for the calculation of gd ($g\ g^{-1}\ d^{-1}$)
$hwgl_i$	auxillary value for the calculation of gd and gl ($g\ g^{-1}\ d^{-1}$)
$hwgld$	auxillary value for the calculation of gd and gl ($g\ g^{-1}\ d^{-1}$)
$ired$	value of iin (incoming radiation) reduced by reflection ($J\ cm^{-2}\ d^{-1}$)
$iredz$	photosynthetic active light in depth $zvonj$ ($J\ cm^{-2}\ d^{-1}$)
$ksrf$	corrected factor for strong rain events or melting snow (correction with respect to reduced erosion in the drainage basin in dependence of the vegetation cover) (-)
kx	half saturation value of the inverse relationship between photosynthesis rate and phytoplankton biomass at phosphate limiting conditions ($g\ m^{-3}$)
kxn	half saturation value of the inverse relationship between photosynthesis rate and phytoplankton biomass at nitrogen limiting conditions ($g\ m^{-3}$)
kz	half saturation value of the inverse relationship between ingestion rate of zooplankton and zooplankton biomass ($g\ m^{-3}$)
kz_i	half saturation value of the inverse relationship between ingestion rate of zooplankton and phytoplankton biomass of group i ($g\ m^{-3}$)
kzd	half saturation value of the inverse relationship between ingestion rate of zooplankton and detritus ($g\ m^{-3}$)

lo	loading of the water body with oxygen-consuming organic matter ($g\ m^{-3}\ d^{-1}$)
$lsez$	loading of the water body due to to oxygen consumption by the sediment ($g\ m^{-3}\ d^{-1}$)
M	number of depth levels for the internal calculation of light and photosynthesis
$miner_i$	mineralisation coefficient related to oxygen consumption by sinking phytoplankton of group i (-)
$minerd$	mineralisation coefficient related to oxygen consumption by sinking detritus (-)
$mortz$	zooplankton mortality rate (d^{-1})
$nexkr$	rate of nitrogen remineralisation by living zooplankton ($g\ N\ m^{-3}\ d^{-1}$)
$nkons$	assimilation of inorganic nitrogen by phytoplankton ($g\ N\ m^{-3}\ d^{-1}$)
$nmort$	rate of nitrogen mineralisation from dead zooplankton and by fish ($g\ N\ m^{-3}\ d^{-1}$)
$nrem$	remineralisation of nitrogen ($g\ N\ m^{-3}\ d^{-1}$)
nsf	release of inorganic nitrogen from the sediment to the water body ($g\ N\ m^{-3}\ d^{-1}$)
o	state variable: oxygen concentration ($g\ m^{-3}$)
$okons$	oxygen consumption (without phytoplankton respiration) ($g\ m^{-3}\ d^{-1}$)
$oprod$	net oxygen production by living phytoplankton ($g\ m^{-3}\ d^{-1}$)
$pexkr$	rate of phosphate remineralisation by zooplankton excretion ($mg\ P\ g\ Z^{-1}\ d^{-1}$)
pf_i	preference factor for ingestion of phytoplankton group i by zooplankton (-)
$photx_i$	gross photosynthesis rate of phytoplankton group i (d^{-1})
$phoxl_i$	term of the relationship between photosynthesis rate of phytoplankton group i and light (-)
$phoxn_i$	term of the relationship between photosynthesis rate of phytoplankton group i and anorganic nitrogen (including dependence on phytoplankton biomass) (-)
$phoxns_i$	term of the relationship between photosynthesis rate of phytoplankton group i and the primary limiting nutrient(including dependence on phytoplankton biomass) (-)
$phoxp_i$	term of the relationship between photosynthesis rate of phytoplankton group i and phosphate (including dependence on phytoplankton biomass) (-)
$phoxt_i$	term of the relationship between photosynthesis rate of phytoplankton group i and temperature (d^{-1})
$pkons$	phosphate consumption by phytoplankton ($mg\ m^{-3}\ d^{-1}$)
$pmort$	rate of phosphate remineralisation from dead zooplankton or zooplankton eaten by fish (d^{-1})
$prem$	remineralisation of phosphate ($mg\ m^{-3}\ d^{-1}$)
$psed$	sedimentation of phosphate by coprecipitation with calcite or other minerals ($mg\ m^{-3}\ d^{-1}$)
psf	release of phosphorus from sediment to the water body ($mg\ m^{-3}\ d^{-1}$)
rx_i	respiration rate of phytoplankton group i (d^{-1})
rxt_i	base respiration rate of phytoplankton group i (d^{-1})
rz	respiration rate of zooplankton (d^{-1})
rzg	factor of zooplankton respiration rate

rzt	factor of zooplankton respiration rate
sat	oxygen concentration at 100% saturation ($g\ m^{-3}$)
$seza$	oxygen consumption of the sediment (per sediment surface area) ($g\ m^{-2}\ d^{-1}$)
$sumxpf$	Summe der Zustände x_i multipliziert mit pf_i
wx_i	growth rate of phytoplankton group i (d^{-1})
wz	growth rate of zooplankton (d^{-1})
$xgraz_i$	phytoplankton loss of group i due to zooplankton grazing ($g\ m^{-3}\ d^{-1}$)
xwa_i	growth of phytoplankton group i ($g\ m^{-3}\ d^{-1}$)
zmo	zooplankton mortality ($g\ m^{-3}\ d^{-1}$)
$zvonj$	depth of layer j (m)
zwa	zooplankton growth ($g\ m^{-3}\ d^{-1}$)

SALMO - System of Equations

Anorganic Nitrogen

Change =
- assimilation of organic nitrogen by phytoplankton
+ remineralisation of nitrogen
+ release of nitrogen from the sediment
+ ...

1.0 $$\frac{dn}{dt} = -nkons + nrem + nsf + nden \qquad \left[\frac{gN}{m^3} \cdot d\right]$$

1.2 $$nkons = \sum \left(\frac{wx_i}{YNX} \cdot x_i\right) + \frac{assiz}{YZN} \cdot RATN \cdot z\ ; \quad i = 1, \ldots, nx$$

1.3 $$nrem = (nmort + nexkr) \cdot z$$

1.4 $$nmort = \frac{mortz \cdot RATNF}{YZN}$$

1.5 $$nexkr = \left(\left(\sum \frac{g_i}{YNX}\right) + \frac{g_d}{YND} + \frac{rz}{YZN}\right) \cdot RATN\ ; \quad i = 1, \ldots, xn$$

1.7 $$nsf = \frac{ansfq - ansfs}{v} \cdot ased$$

1.8 $$ansfs = \begin{cases} NDSMAX \cdot \dfrac{n}{KNDS + n} \cdot KNDST^{(temp-4)}\ ; & NDSSTART \leq t < NDSEND \\ ANSFMIN + KANSF \cdot temp\ ; & \text{sonst} \end{cases}$$

$$ansfq = \begin{cases} ANSFMIN\ ; & NDSSTART \leq t < NDSEND \\ 0\ ; & \text{sonst} \end{cases}$$

3.8 $$nden = \frac{n \cdot KDEN \cdot lo}{KNDS + n}\ ; \quad n > 0,\ 0 \leq LINDEN$$

Dissolved Inorganic Phosphorus

Change =
- phosphate uptake by phytoplankton
+ remineralisation
+ ...
+ release of phosphate from sediment

4.0 $$\frac{dp}{dt} = -pkons + prem + presp + psf \qquad \left[\frac{mg}{m^3} \cdot d\right]$$

4.3 $$pkons = \sum \left(\frac{photx_i}{YX_i} \cdot x_i \right) + \frac{assiz}{YZP} \cdot RAT \cdot z \ ; \quad i = 1, \ldots, nx$$

4.4 $$prem = (pmort + pexkr) \cdot z$$

$$presp = \sum \left(\frac{rx_i}{YX_i} \cdot x_i \right) \ ; \quad i = 1, \ldots, nx$$

4.5 $$pmort = \frac{mortz \cdot RATF}{YZP}$$

4.6 $$pexkr = \left(\left(\sum \frac{g_i}{YX_i} \right) + \frac{g_d}{YD} + \frac{rz}{YZP} \right) \cdot RAT \ ; \quad i = 1, \ldots, xn$$

4.9 $$psf = apsf \cdot \frac{ased}{v}$$

4.10 $b_1 = n - 0.3 \cdot LINDEN$

$$b_2 = o + \frac{n}{0.3} - LINDEN$$

$if(npsfmode = TRUE)$

$$apsf = \begin{cases} APSFMAX\ ; & b_1 \leq 0 \\ APSFMAX \cdot \dfrac{\frac{1}{b1}}{\frac{1}{(KAPSF - 0.3 \cdot LINDEN)} + \frac{1}{b_1}}\ ; & b_1 > 0 \end{cases}$$

$else$

$$apsf = \begin{cases} APSFMAX\ ; & b_2 \leq 0 \\ APSFMAX \cdot \dfrac{\frac{1}{b_2}}{\frac{1}{(KAPSF - LINDEN)} + \frac{1}{b_2}} + APSFMIN\ ; & b_2 > 0 \end{cases}$$

Light in the Water Column

7.0 $iredz(j) = ired \cdot \exp(-eps \cdot z(j)) \qquad \left[\frac{J}{cm^2} \cdot d\right]$

7.1 $ired = iin$

7.2 $eps = eps' + \left(\sum (EPSX_i \cdot x_i) + EPSD \cdot d\right)\ ; \quad i = 1, \ldots, nx$

7.3 $eps' = \begin{cases} EPSMIN + EPSR \cdot (ksrf - KSRFMAX)\ ; & qin > 0,\ ksrf > KSRFMAX \\ EPSMIN\ ; & \text{sonst} \end{cases}$

7.4 $ksrf = \left(1.5 + 0.5 \cdot \cos\left((t - 30) \cdot \frac{\pi}{180}\right)\right) \cdot srf$

7.5 $z(j) = z(j-1) \cdot \frac{zmix}{M}\ ; \quad M = \max\left(2, \frac{zmix}{ZLIGHT}\right)$

Phytoplankton

Change =
+ growth of phytoplankton
- sedimentation of phytoplankton
- grazing by zooplankton

9.0 $$\frac{dx_i}{dt} = xwa_i - xsed_i - xgraz_i \; ; \quad i = 1, \ldots, nx \qquad \left[\frac{g}{m^3} \cdot d\right]$$

9.1 $$xwa_i = wx_i \cdot x_i$$

9.2 $$wx_i = \frac{1}{M} \cdot \sum_{j=1}^{M} wx(j)_i$$

9.3 $$M = max\left(2, \frac{zmix}{ZLIGHT}\right)$$

9.4 $$wx(j)_i = photx_i(j) - rx_i(j)$$

9.5 $$photx_i(j) = phoxt_i \cdot phoxl_i(j) \cdot phoxns_i$$

9.6 $$phoxns_i = \begin{cases} phoxn_i \; ; & \frac{n}{p} \leq OPTNP \; \& \; NFIX_i < 1e-4 \\ phoxp_i \; ; & \text{sonst} \end{cases}$$

9.7 $$phoxt_i = \frac{(PHOTXMAX_i - PHOTXMIN_i)}{TOPTX_i} \cdot temp + PHOTXMIN_i$$

9.8 $$phoxl_i = \begin{cases} \dfrac{iredz(j) \cdot (1 - NFIX_i)}{KI_i + iredz(j)} \; ; & \dfrac{n}{p} < OPTNP \\ \dfrac{iredz}{KI_i + iredz} \; ; & \text{sonst} \end{cases}$$

9.9 $$phoxp_i = \frac{p}{x_i \cdot \left(\frac{KP_i}{kx} + \frac{p}{kx} + \frac{KP_i}{x_i} + \frac{p}{x_i}\right)}$$

9.10 $$kx = \begin{cases} LXL \cdot p^{MXL} \; ; & p \leq WPKX \\ KXMIN + LXH \cdot p^{MXH} \; ; & p > WPKX \end{cases}$$

9.11 $$phoxn_i = \frac{n}{x_i \cdot \left(\frac{KN_i}{kxn} + \frac{n}{kxn} + \frac{KN_i}{x_i} + \frac{n}{x_i}\right)}$$

9.12 $$kxn = \begin{cases} LXLN \cdot n^{MXL} \; ; & n \leq WPKX \cdot OPTNP \\ KXMIN + LXHN \cdot n^{MXH} \; ; & n > WPKX \cdot OPTNP \end{cases}$$

9.13 $$rx_i(j) = rxt_i + RXMF \cdot photx_i(j)$$

9.14 $$rxt_i = \frac{RXTOPT_i - RXTMIN_i}{TOPTX_i} \cdot temp + RXTMIN_i$$

9.16 $$xsed_i = bx_i \cdot x_i$$

9.17 $$bx_i = \begin{cases} \frac{VS_i}{zmix} \cdot SF \cdot (1 - aver) \; ; & tief > ZRES \\ 0 \; ; & \text{sonst} \end{cases}$$

9.18 $$xgraz_i = g_i \cdot z$$

9.19 $$g_i = \frac{hwg_i}{\sum hwg_i + hwg_d} \cdot g$$

$$g_d = \frac{hwg_d}{\sum hwg_i + hwg_d} \cdot g$$

9.20 $$hwg_i = hwgd_i$$
$$hwg_d = hwgd_d$$

9.21 $$hwgd_i = gdt \cdot hwgdb_i$$
$$hwgd_d = gdt \cdot hwgdb_d$$

9.22 $$gdt = (GMAX - GMIN) \cdot \left(\exp\left(-R \cdot \mathrm{abs}\left(\ln\left(\frac{temp}{TOPTZ}\right)\right)\right)\right) + GMIN$$

9.23 $$hwgdb_i = \frac{x_i \cdot pf_i}{z \cdot \left(\frac{KXG}{kz_i} + \frac{x_i}{kz_i} + \frac{KXG}{z} + \frac{x_i}{z}\right)}$$
$$hwgdb_d = \frac{d \cdot PF}{z \cdot \left(\frac{KXG}{kz_d} + \frac{d}{kz_d} + \frac{KXG}{z} + \frac{d}{z}\right)}$$

9.24 $$kz_i = \begin{cases} LGL \cdot (x_i \cdot pf_i)^{MGL} \ ; & x_i \cdot pf_i \leq WPKZ \\ KZMIN + LGH \cdot (x_i \cdot pf_i)^{MGH} \ ; & x_i \cdot pf_i > WPKZ \end{cases}$$
$$kz_d = \begin{cases} LGL \cdot (d \cdot PF)^{MGL} \ ; & d \cdot PF \leq WPKZ \\ KZMIN + LGH \cdot (d \cdot PF)^{MGH} \ ; & d \cdot PF > WPKZ \end{cases}$$

9.25 $$b_3 = \sum_{i+1}^{nx} x_i - PFX_i$$
$$pf_i = \begin{cases} PFC_i \ ; & i = nx \\ const = 1 \ ; & i = nx-1, \ldots, 1, \ b_3 \leq 0 \\ \dfrac{1}{b_3 \cdot \left(\frac{1}{(KPF_i - PFX_i)} + \frac{1}{b_3}\right)} \ ; & i = nx-1, \ldots, 1, \ b_3 > 0 \end{cases}$$

9.29 $$gd = gdt \cdot gdb$$

9.30 $$gdb = \left(\frac{\sum x_i \cdot pf_i + d \cdot PF}{z \cdot \left(\frac{KXG}{kz} + \frac{\sum x_i \cdot pf_i + d \cdot PF}{kz} + \frac{KXG}{z} + \frac{\sum x_i \cdot pf_i + d \cdot PF}{z} \right)} \right)$$

9.31 $$kz = \begin{cases} LGL \cdot (\sum x_i \cdot pf_i + d \cdot PF)^{MGL} \;; & \sum x_i \cdot pf_i + d \cdot PF \leq WPKZ \\ KZMIN + LGH \cdot (\sum x_i \cdot pf_i + d \cdot PF)^{MGH} \;; & \sum x_i \cdot pf_i + d \cdot PF > WPKZ \end{cases}$$

Zooplankton

Change =
+ growth of zooplankton
- mortality

12.0 $$\frac{dz}{dt} = zwa - zmo \qquad \left[\frac{g}{m^3} \cdot d \right]$$

12.1 $$zwa = wz \cdot z$$

12.2 $$egg = \begin{cases} \frac{DTMIN}{dt} \;; & dt \geq DTMIN \\ 1 \;; & dt < DTMIN \end{cases}$$

12.3 $$dt = \exp\left(DTA - DTB \cdot \ln(temp) - DTC \cdot (\ln(temp))^2 \right)$$

12.4 $$wz = (assiz - rz) \cdot egg$$

12.5 $$assiz = az \cdot \left(\sum g_i \cdot UXZ_i + g_d \cdot UXZD \right) \;; \quad i = 1, \ldots, nx$$

12.6 $az = \left(AZMAX - \frac{AZMAX - AZMIN}{GMAX} \cdot g \right)$

12.7 $rz = rzg \cdot rzt$

12.8 $rzg = \left(\frac{RZOPT - RZMIN}{GMAX} \cdot g + RZMIN \right) \cdot \frac{1}{RZOPT}$

12.9 $rzt = (RZOPT - RZTMIN) \cdot \left(\frac{temp}{TOPTZ} \right)^2 + RZTMIN$

12.11 $zmo = mortz \cdot z$

12.12 $mortz = (MOMIN + MOT \cdot temp) \cdot \frac{z}{KMO + z}$

Oxygen

15.1 $T_k = temp + 273.5$

$$sat = \exp(-139.34411 + 157570.1 \cdot T_k - 66423080 \cdot T_k^2 + 12438000000 \cdot T_k^3 - 862194900000 \cdot T_k^4)$$

Change =
+ netto oxygen production by phytoplankton
- oxygen consumption (without respiration part of phytoplankton)

16.0 $\frac{do}{dt} = oprod - okons \qquad \left[\frac{g}{m^3} \cdot d \right]$

16.4 $oprod = \sum \left(\frac{wx_i}{YOX} \cdot x_i \right) \; ; \quad i = 1, \ldots, nx$

16.5 $okons = \frac{lo}{YOX}$

16.6 $lo = \sum xsed_i + rz \cdot z + lsez\ ; \quad i = 1, \ldots, nx$

16.7 $\sum xsed_i = \sum \left(\frac{VS_i \cdot x_i \cdot miner_i}{zmix} \right) + \frac{VD \cdot d \cdot miner_d}{zmix}\ ; \quad i = 1, \ldots, nx$

16.8 $$miner_i = \begin{cases} KMINER \cdot \frac{zmix}{VS_i}\ ; & miner_i \leq 1 \\ 1\ ; & miner_i > 1 \end{cases}\ ; \quad i = 1, \ldots, nx$$

$$miner_d = \begin{cases} KMINER \cdot \frac{zmix}{VD}\ ; & miner_d \leq 1 \\ 1\ ; & miner_d > 1 \end{cases}\ ; \quad d = \max\left(1, KMINER \cdot \frac{zmix}{VD}\right)$$

16.9 $lsez = seza \cdot YOK \cdot \frac{ased}{v}$

16.10 $seza = (neuerParameter) \cdot \exp(0.08 \cdot temp) \cdot \frac{o}{KSEZA + o}$

Detritus

Change =
- grazing by zooplankton

18.0 $\frac{dd}{dt} = -dgraz \qquad \left[\frac{g}{m^3} \cdot d\right]$

18.4 $dgraz = g_d \cdot z$