

CEE 577: Surface Water Quality Modeling

Lecture #27

Limnology (cont.): Other Mechanistic
Models

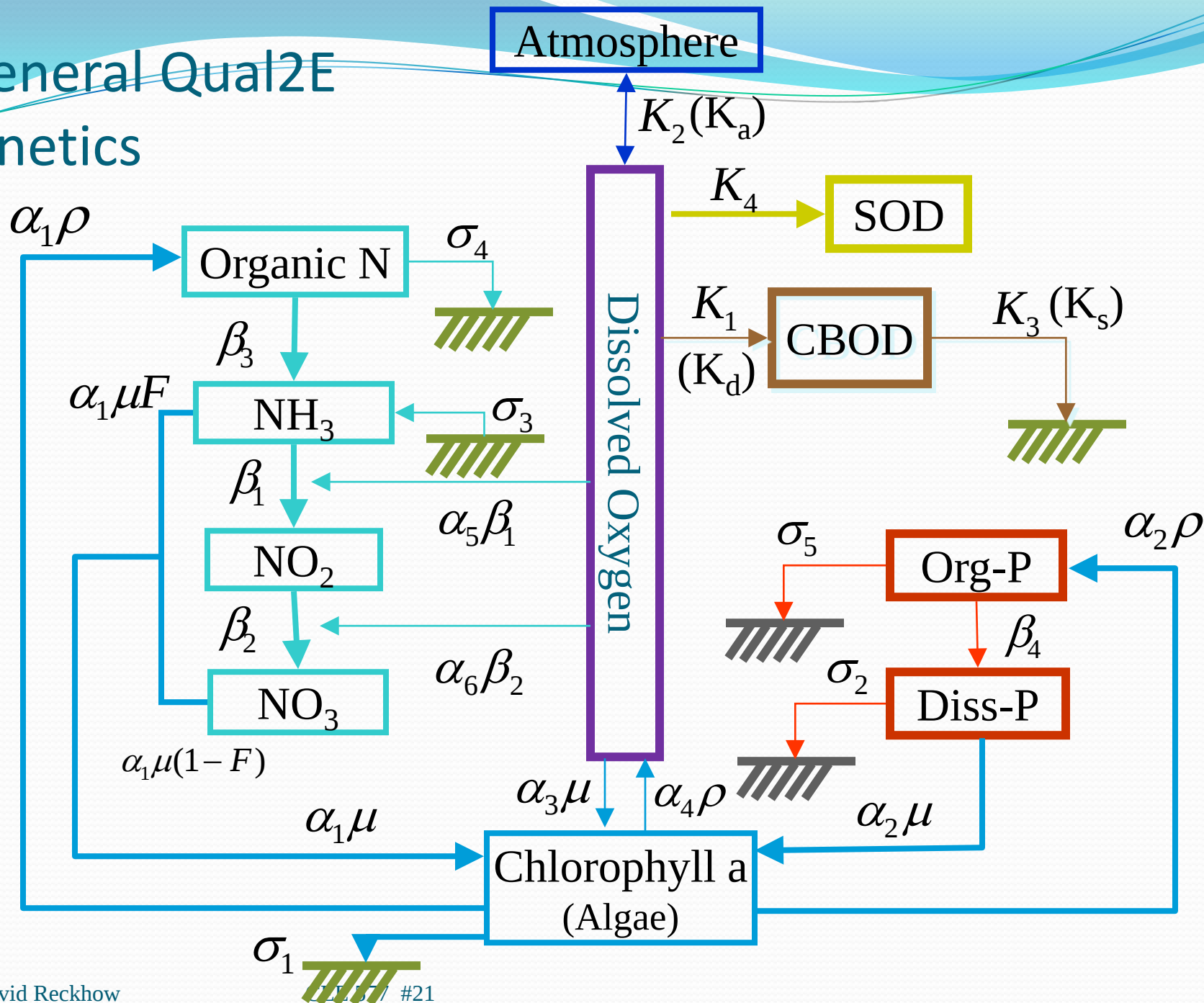
(Chapra, L26 & L29)

Mechanistic Nutrient Models

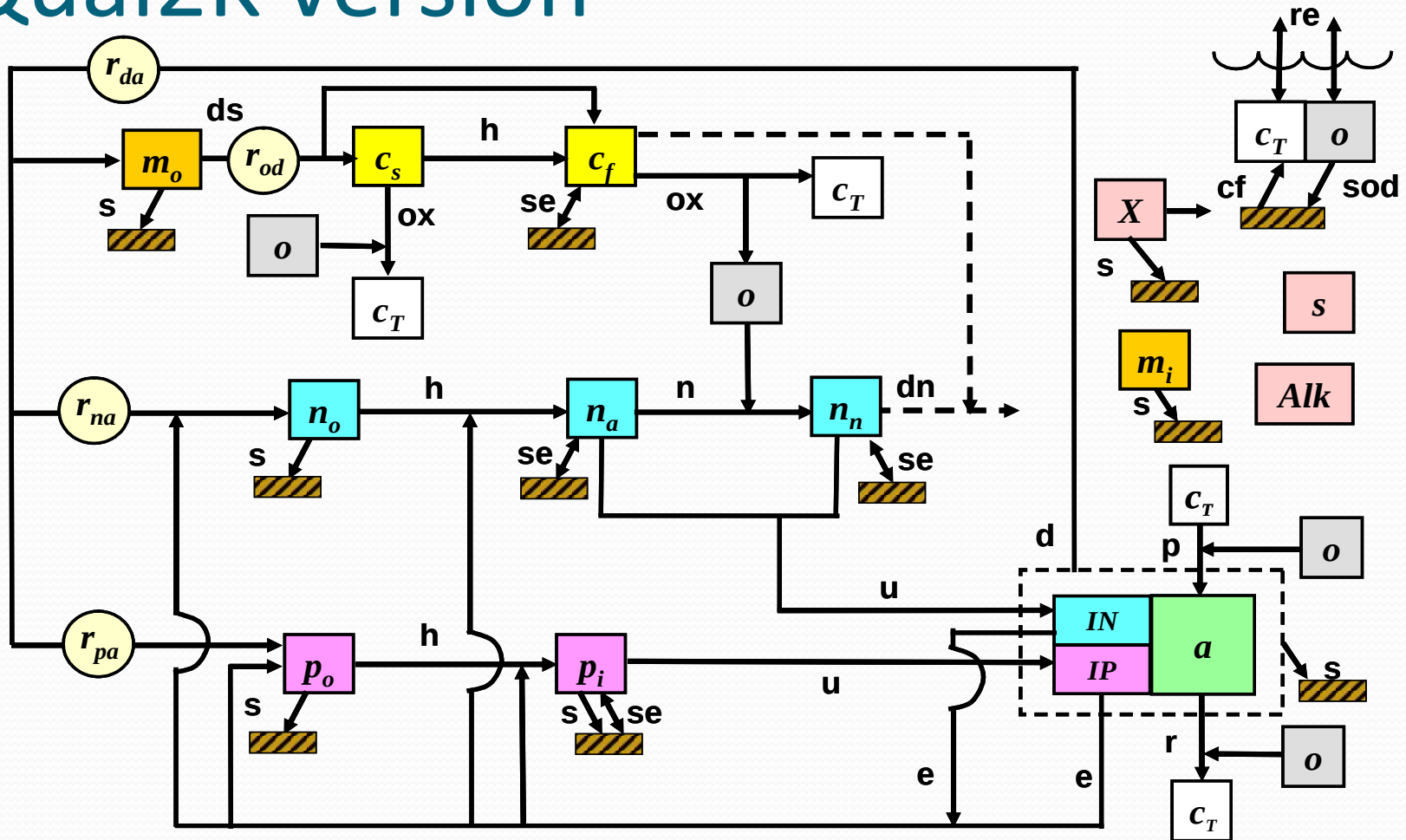
- Qual2E/Qual2K
 - Rivers: 1 dimensional
 - DOC compartments expanded in 2K – like WQMCB
- CE-QUAL-W2
 - Reservoir, Estuary: 2 dimensional (longitudinal-vertical)
- Cannonsville Reservoir Model
- WQDPM (Water Quality Diss. Part. Model)
 - 3 dimensional
 - Coupled to GLLVHT Hydrodynamics
 - Generalized Longitudinal Lateral Vertical Hydrodynamic and Transport model
 - 11 constituents
 - Separates Org-N and Org-C into dissolved and particulate

General Qual2E

Kinetics



Qual2K version



Kinetic processes are dissolution (ds), hydrolysis (h), oxidation (ox), nitrification (n), denitrification (dn), photosynthesis (p), respiration (r), excretion (e), death (d), respiration/excretion (rx). Mass transfer processes are reaeration (re), settling (s), sediment oxygen demand (SOD), sediment exchange (se), and sediment inorganic carbon flux (cf)

Q2K state Variables

Variable	Symbol	Units*
Conductivity	s	μmhos
Inorganic suspended solids	m_i	mgD/L
Dissolved oxygen	o	mgO_2/L
Slowly reacting CBOD	c_s	mgO_2/L
Fast reacting CBOD	c_f	mgO_2/L
Organic nitrogen	n_o	$\mu\text{gN/L}$
Ammonia nitrogen	n_a	$\mu\text{gN/L}$
Nitrate nitrogen	n_n	$\mu\text{gN/L}$
Organic phosphorus	p_o	$\mu\text{gP/L}$
Inorganic phosphorus	p_i	$\mu\text{gP/L}$
Phytoplankton	a_p	$\mu\text{gA/L}$
Phytoplankton nitrogen	IN_p	$\mu\text{gN/L}$
Phytoplankton phosphorus	IP_p	$\mu\text{gP/L}$
Detritus	m_o	mgD/L
Pathogen	X	$\text{cfu}/100 \text{ mL}$
Total inorganic carbon	c_T	mole/L
Bottom algae biomass	a_b	mgA/m^2
Bottom algae nitrogen	IN_b	mgN/m^2
Bottom algae phosphorus	IP_b	mgP/m^2

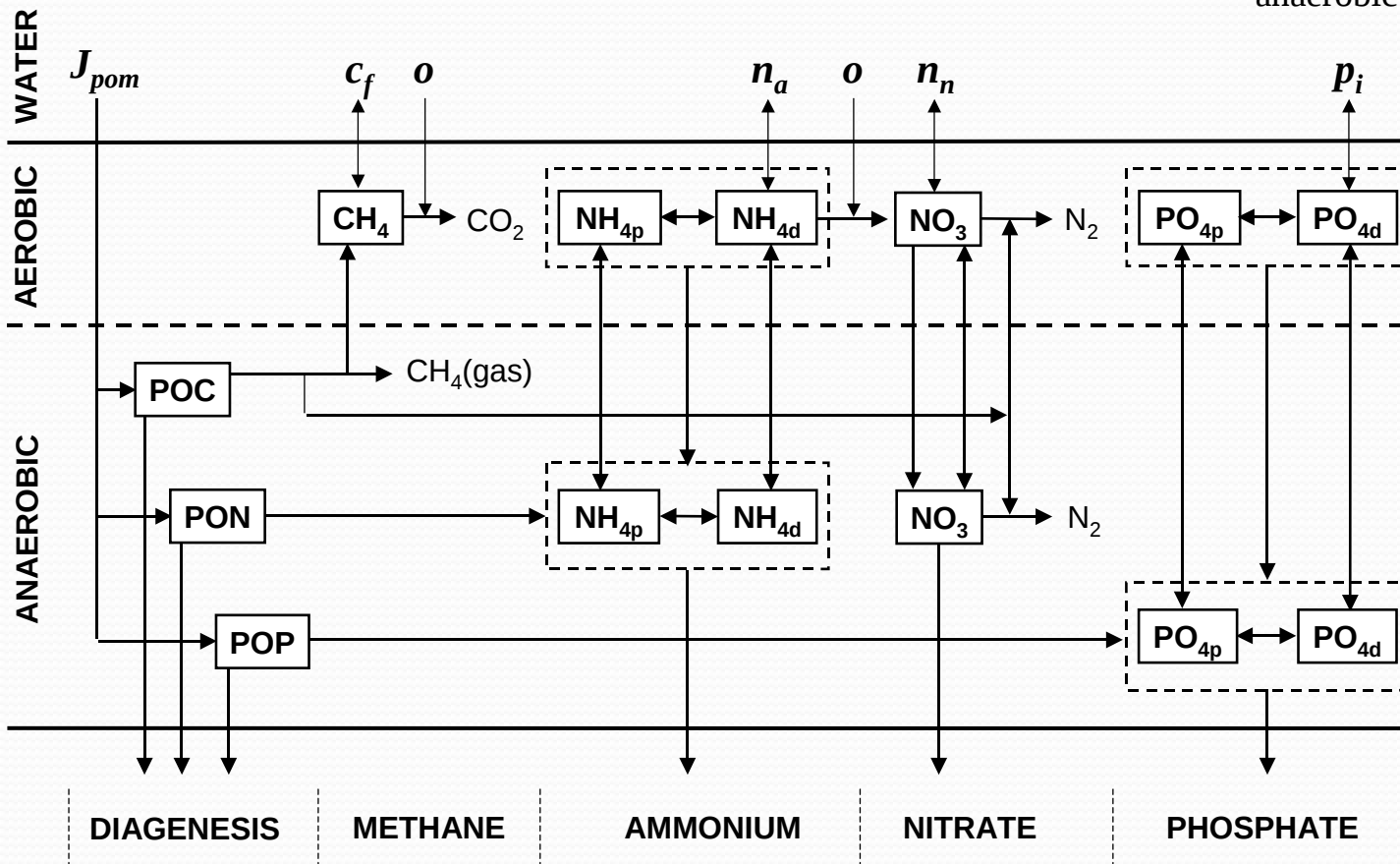
D, C, N, P, and A refer to dry weight, carbon, nitrogen, phosphorus, and chlorophyll a , respectively

Note:

- fast and slow CBOD
- dissolved P is now inorganic P
- nitrite is dropped

Q2K Sediment Model

“The sediments are divided into 2 layers: a thin ($\cong 1$ mm) surface aerobic layer underlain by a thicker (10 cm) lower anaerobic layer.”

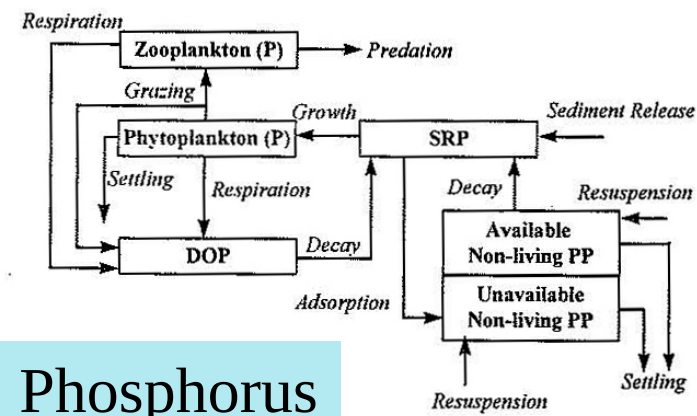


“Organic carbon, nitrogen and phosphorus are delivered to the anaerobic sediments via the settling of particulate organic matter (i.e., phytoplankton and detritus). There they are transformed by mineralization reactions into dissolved methane, ammonium and inorganic phosphorus. These constituents are then transported to the aerobic layer where some of the methane and ammonium are oxidized. The flux of oxygen from the water required for these oxidations is the sediment oxygen demand.”

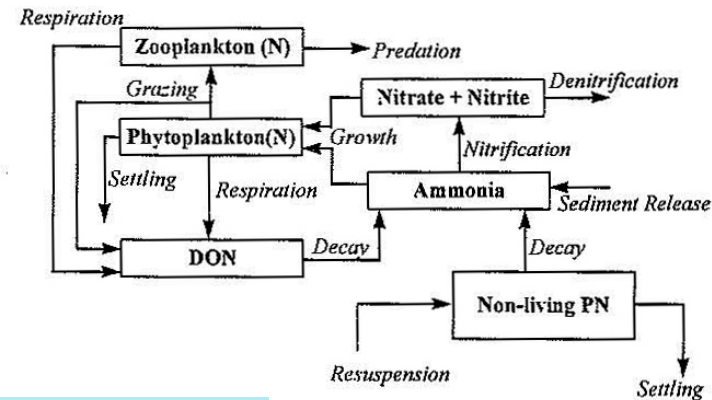
From Chapra, Pelletier & Tao, 2008

Cannonsville Model

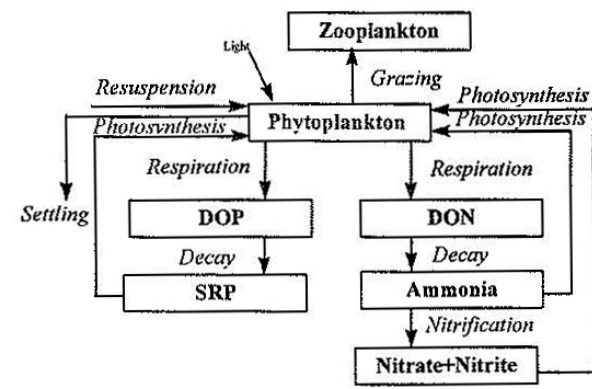
Phosphorus



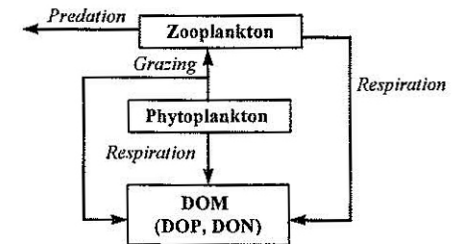
Nitrogen



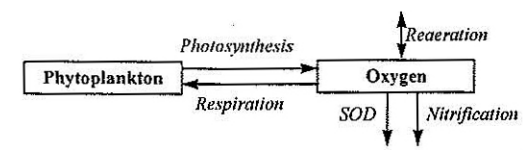
Phytoplankton



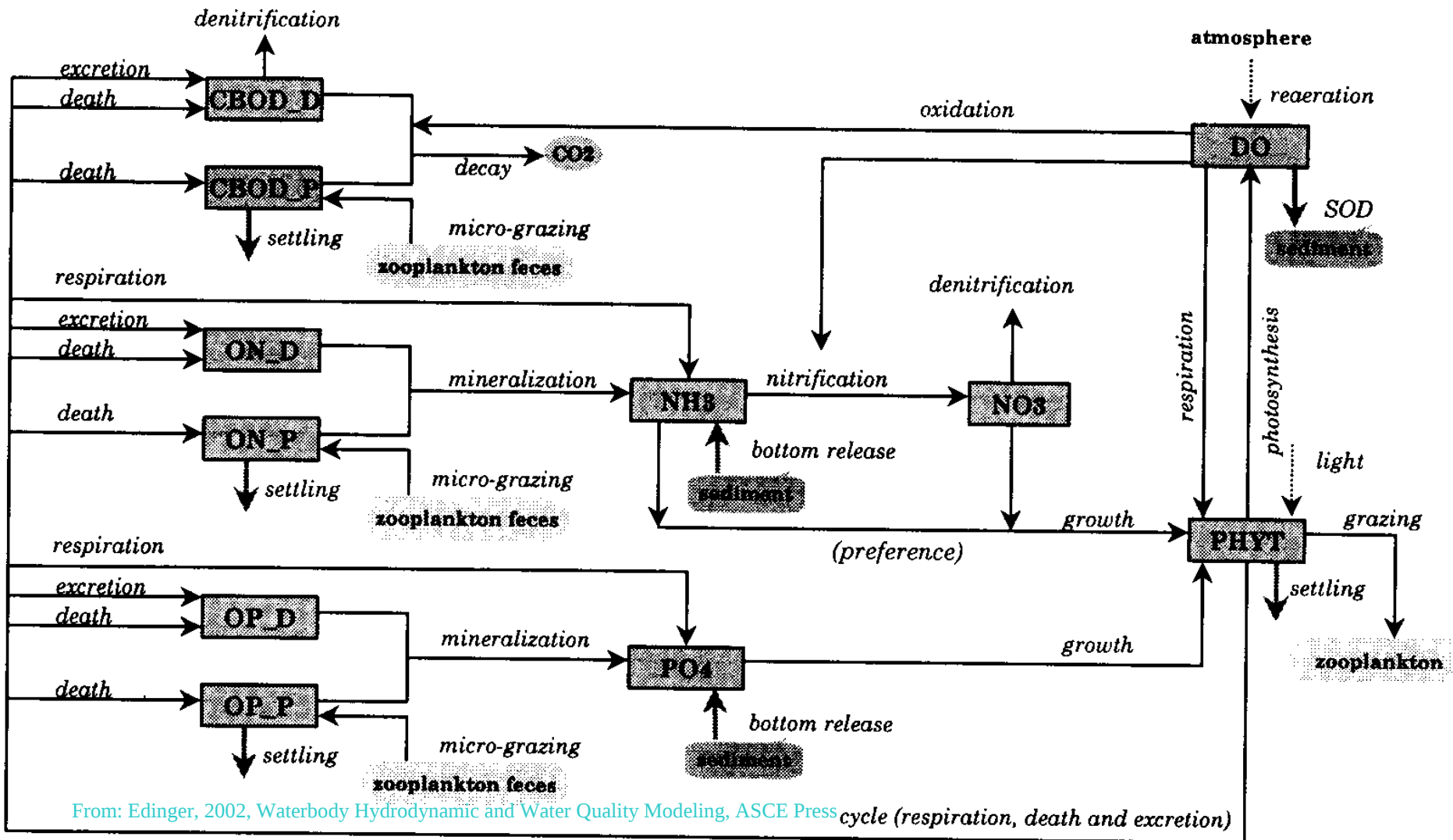
Zooplankton



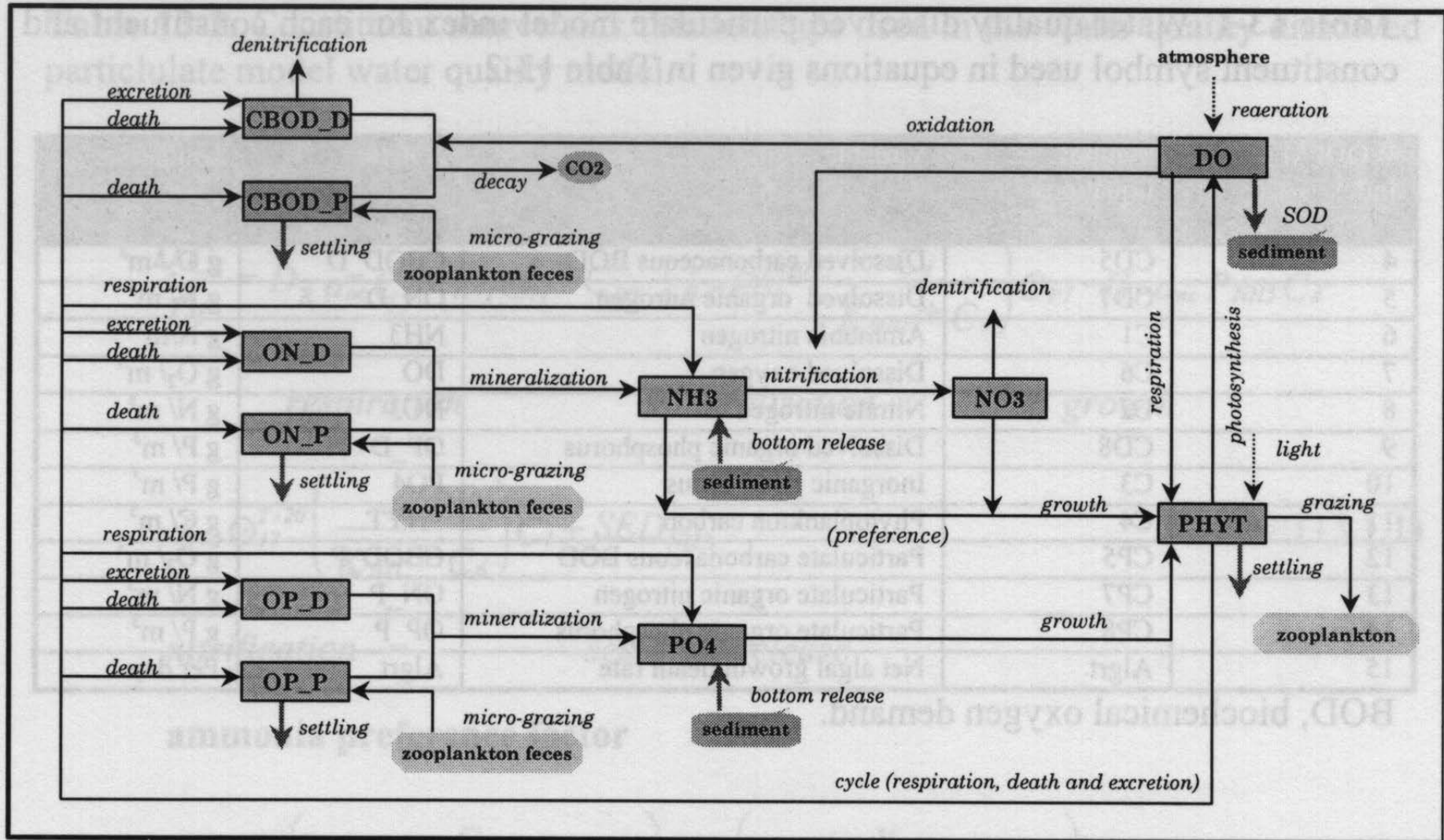
Dissolved O₂



WQDPM Model



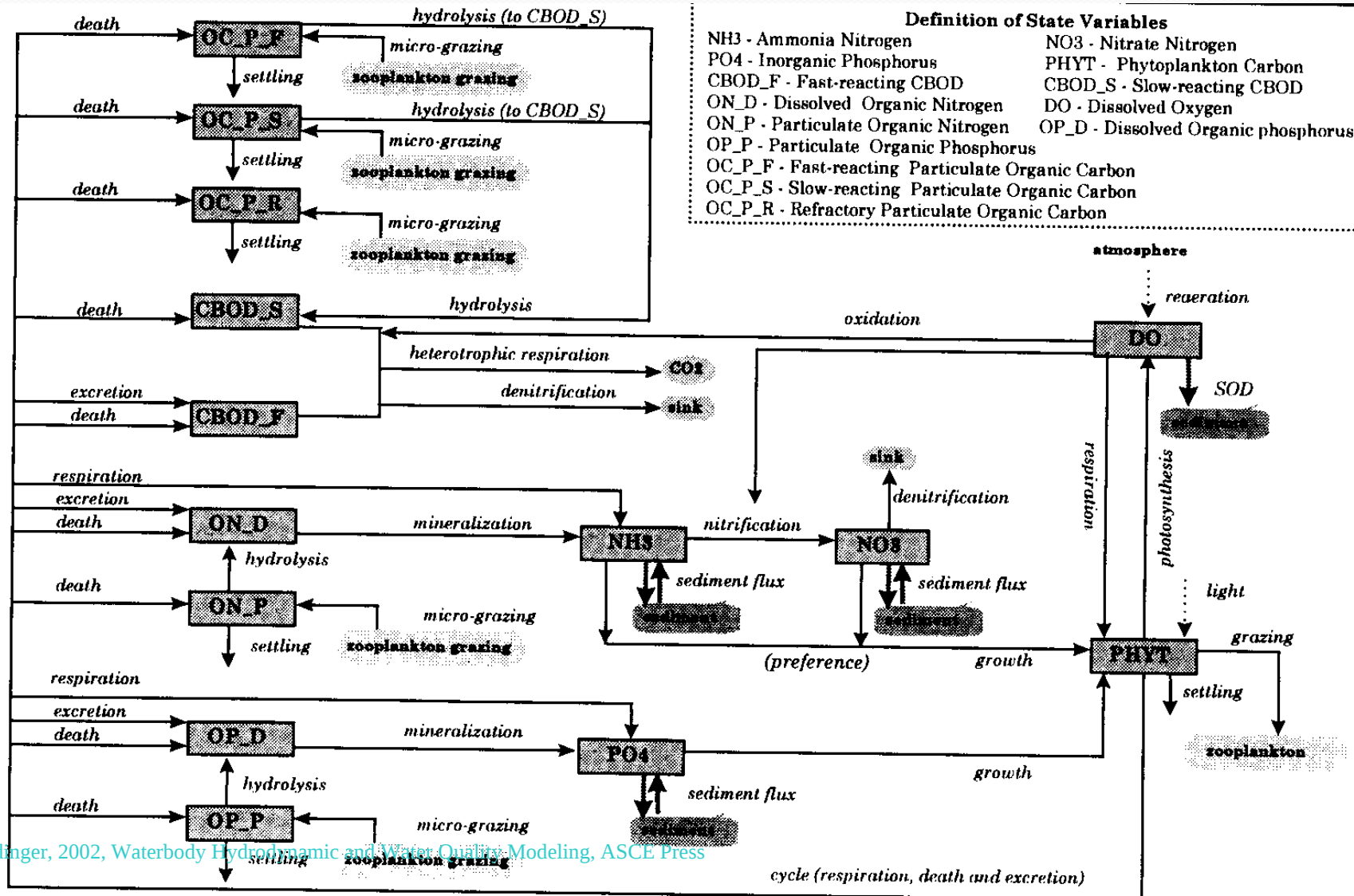
WQDPM Model



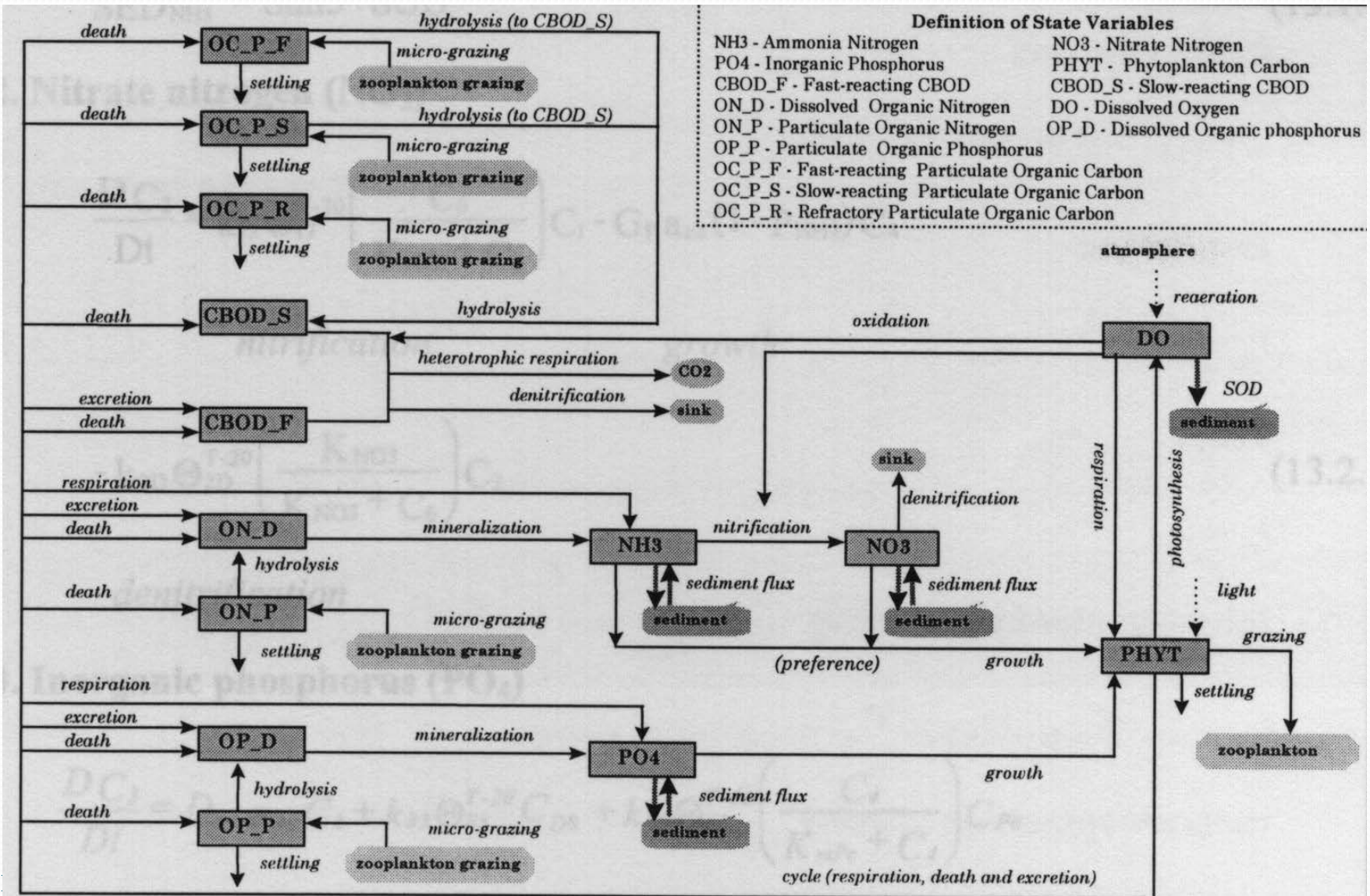
Higher-Order Carbon Model

- WQMCB
 - Expands organic carbon fractions –
 - adopted for use by new QUAL2K visual basic version
 - Fast-reacting (dissolved and particulate)
 - Slow-reacting (dissolved and particulate)
 - Refractory (particulate only)
 - 14 constituents

WQMCB model



WQMCB model



- To next lecture