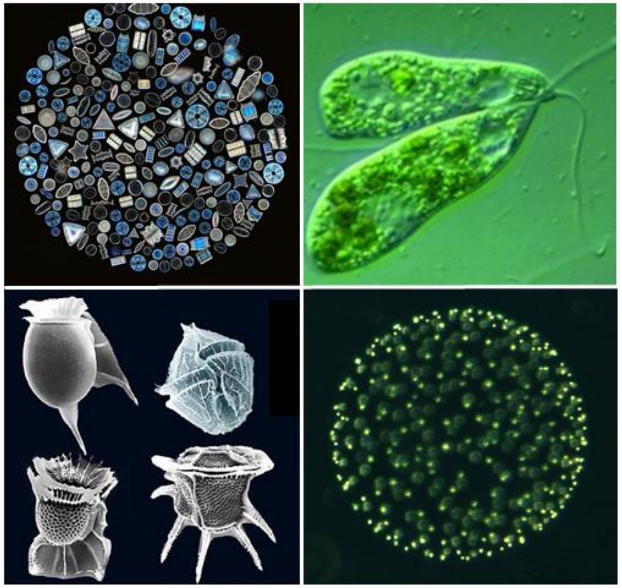
Modelling of Algae in Delft3D-WAQ

General introduction on algae growth



WAQ_Algae_03

General introduction on algae growth (1)

General aspects of algae growth:

- requirements for growth
- seasonal dynamics
- gradients (horizontal, vertical)

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General introduction on algae growth (2)

Algae need for their growth:

- macronutrients (nitrogen, phosphorus, silicate)
- micronutrients (vitamins, iron, etc.)
- light

Simple conclusion (**too simple**):

- ➢ the more nutrients, the more algae
- ➢ the more light, the more algae

Algae species groups in the GEM North Sea application

Diatoms			Flagalletas			Dinoflagelates			Phaeocystis		
Diat E	Diat N	Diat P	Flag E	Flag N	Flag P	Dino E	Dino N	Dino P	Phae E	Phae N	Phae P

General introduction on algae growth (3)

If there is no phosphorus in the water, additional nitrogen will not increase algae concentrations.

Phosphorus is then the *limiting factor*

Algal strategies to cope with limiting factors:

- more efficient use of the limiting factor
- storage of nutrients or energy

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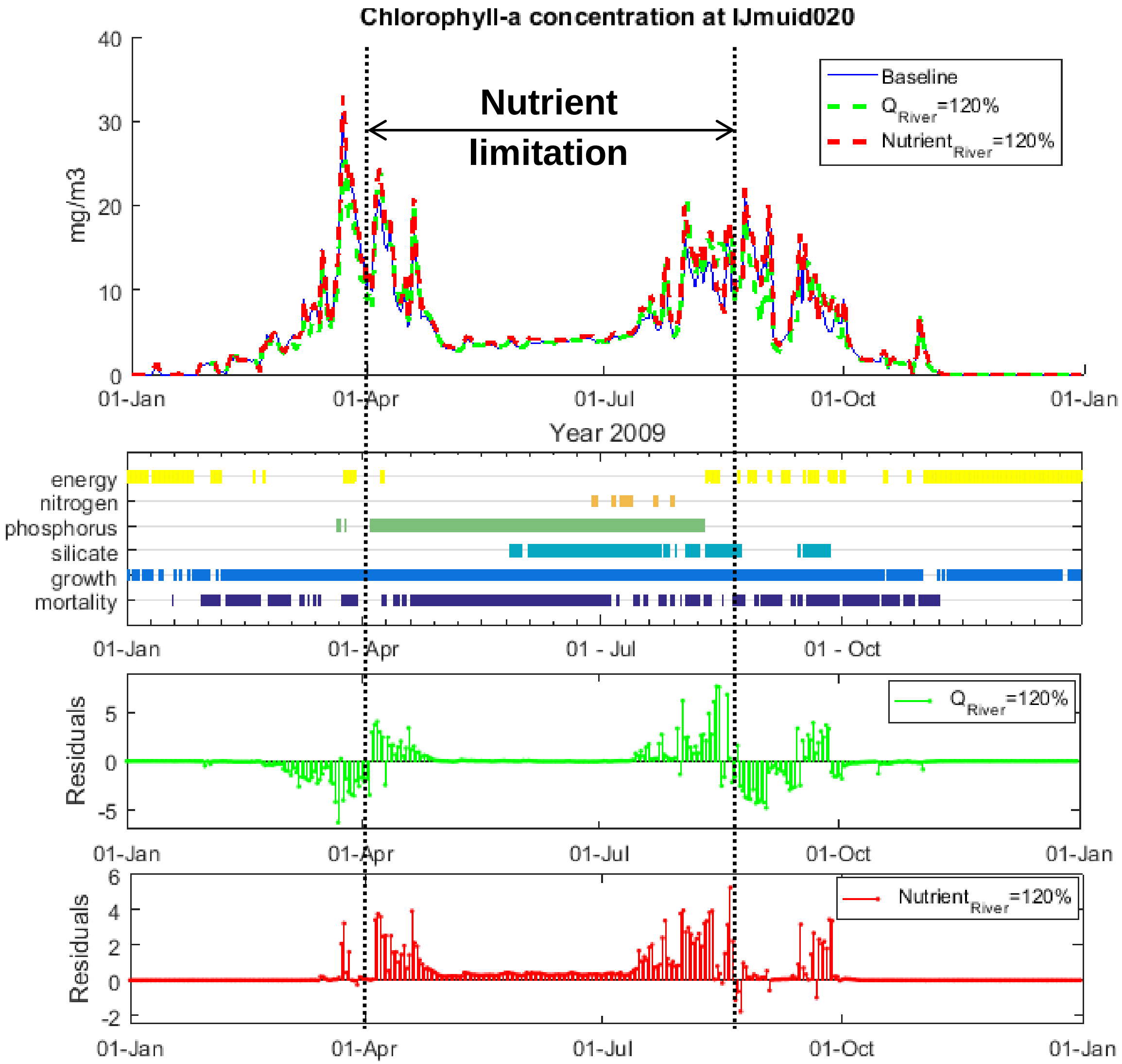
General introduction on algae growth (3)



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General introduction on algae growth (4)

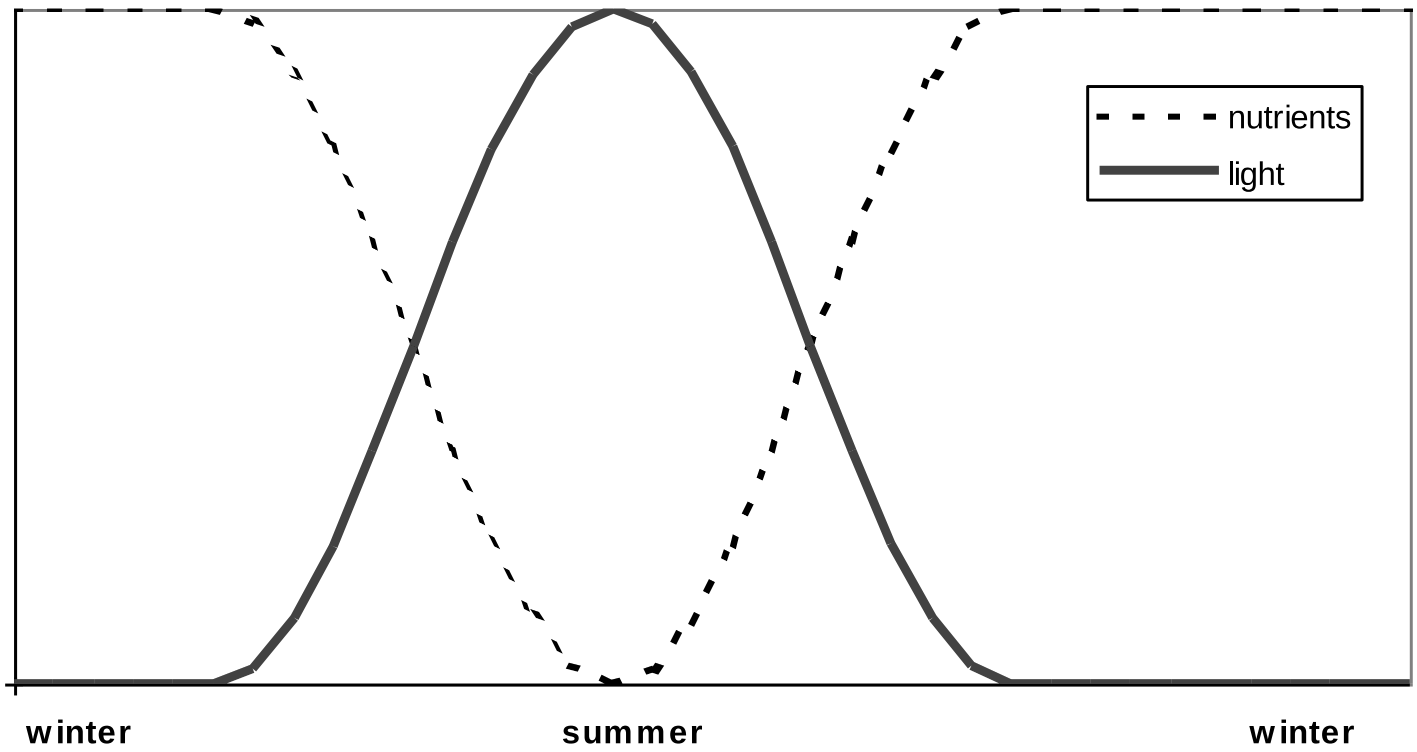
Shifts in limiting factors lead to:

adaptations of algal physiology

shifts in species composition towards species that are better adapted (for example shift to flagellates when silica is exhausted)

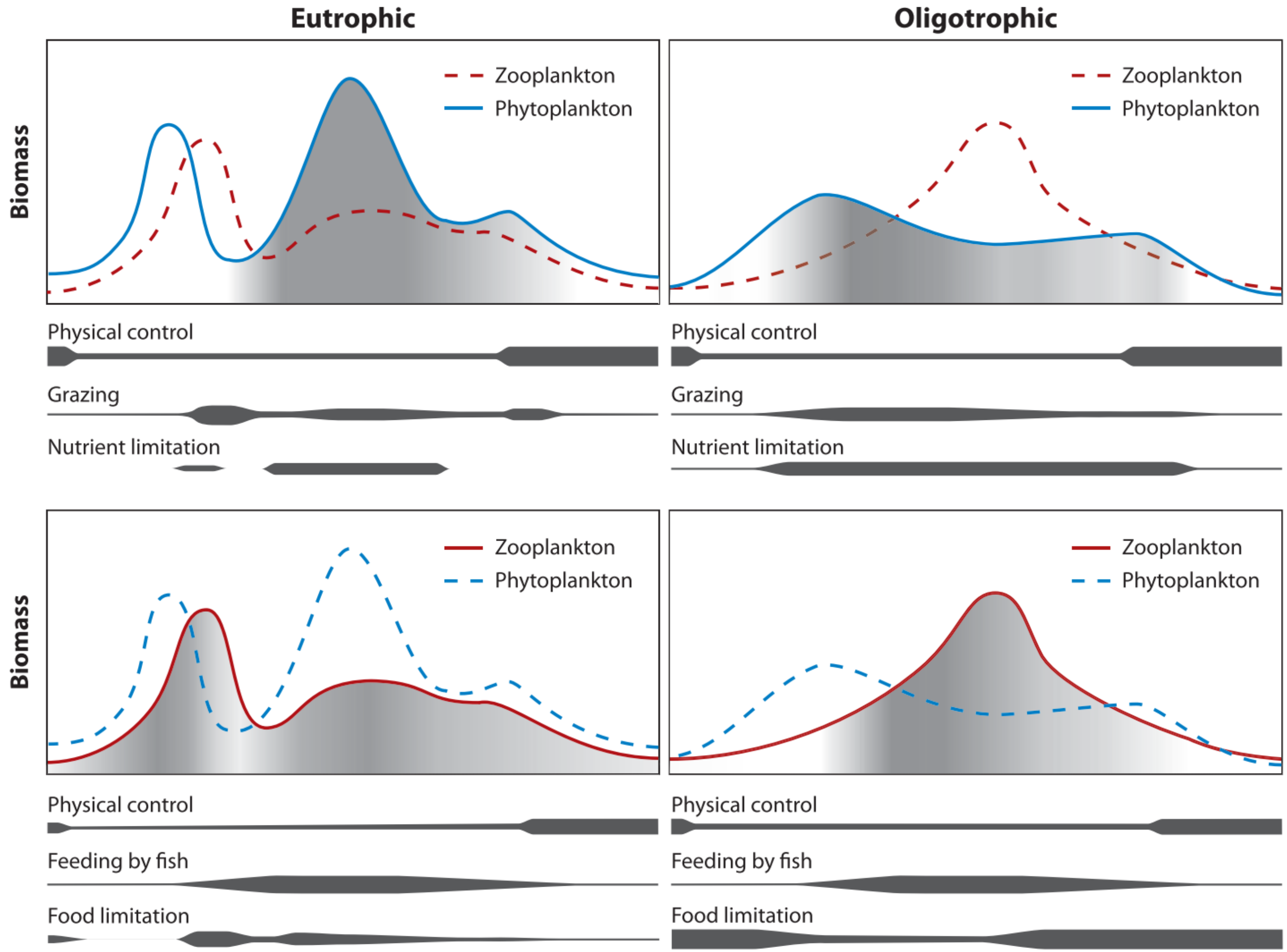
General introduction on algae growth (5)

Seasonal dynamics:



General introduction on algae growth (5)

Seasonal dynamics:



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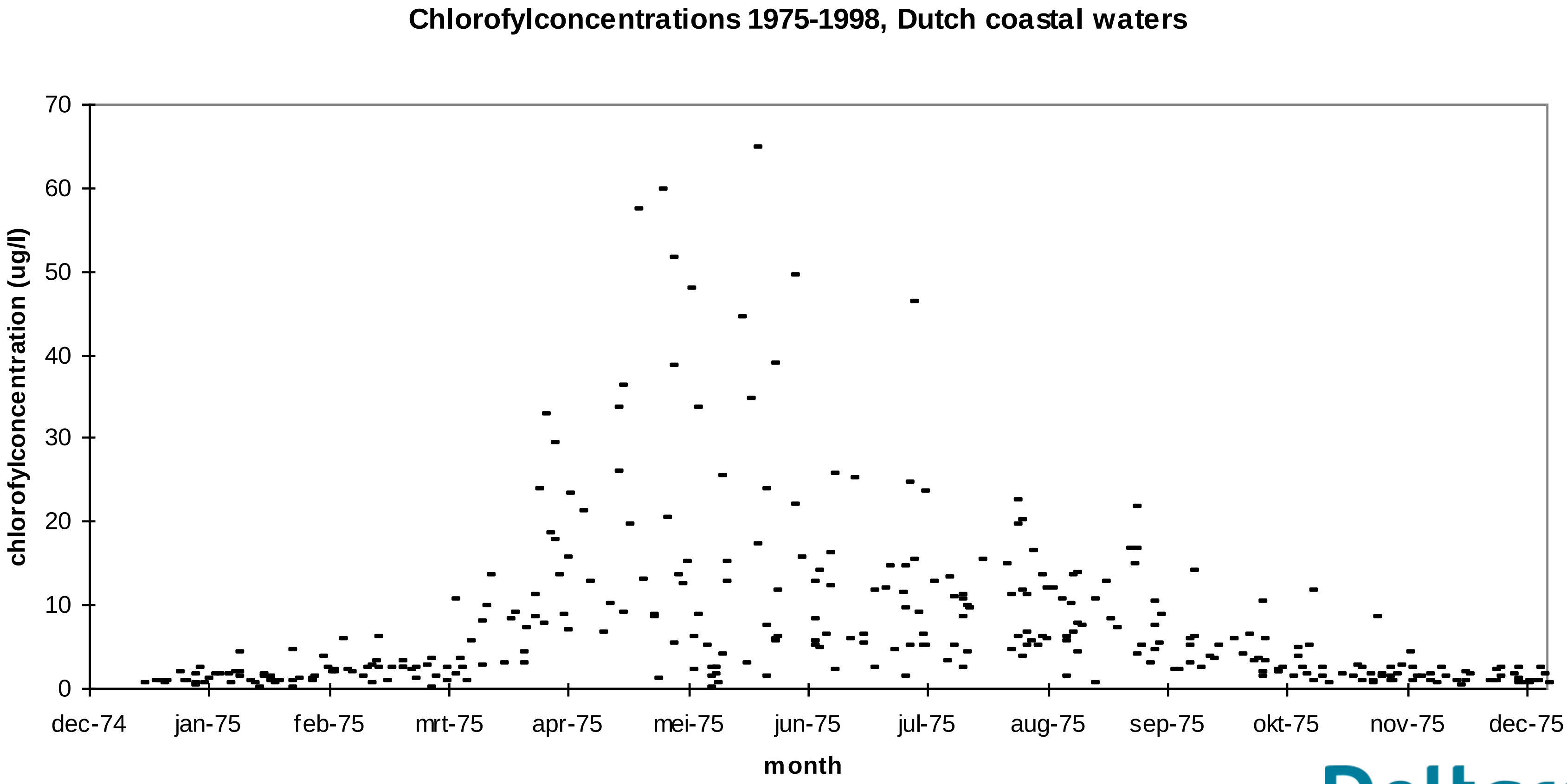
General introduction on algae growth (6)

Dutch coastal waters



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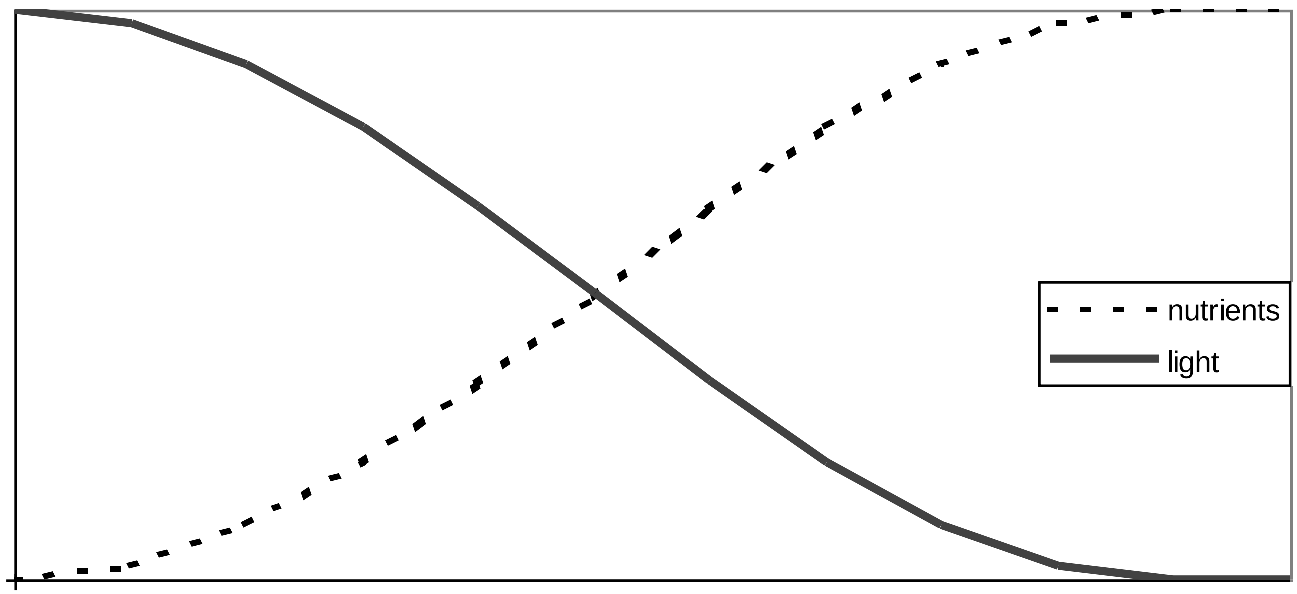
General introduction on algae growth (7)

Horizontal gradients in coastal waters:



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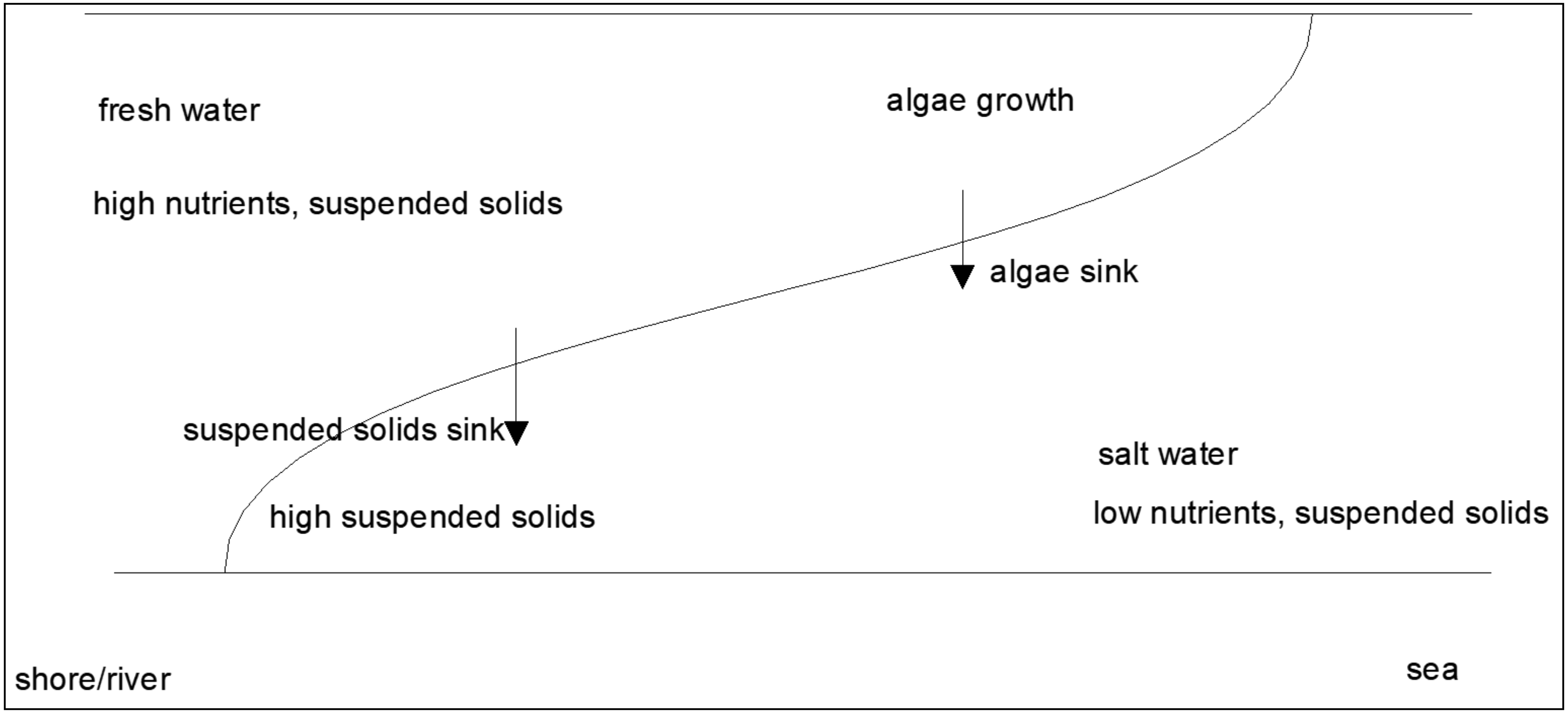
General introduction on algae modelling (8)

Vertical gradients in an estuary:



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Enabling Delta Life

Algal physiology and WAQ-approach

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Algal physiology and WAQ-approach

Processes associated with algae growth:

uptake and release of nutrients and oxygen

growth: increase of biomass

mortality: decrease in biomass

respiration, energy for metabolism

Biomass increase = growth - mortality - respiration

(unity for algae is not numbers but biomass: gram carbon)

Algal physiology and WAQ-approach

Uptake and release of nutrients is proportional to the biomass created or released, according to the (fixed) stochiometry.

Release of nutrients during mortality:

autolysis fraction: inorganic nutrients

detritus fraction: organic decaying nutrients

other organic compounds: slow decay

No.	Parameter	Description
1	ExtVlIM1	Specific Extinction coeff. of suspended inorganic matter
2	PPMaxMDI_E	Maximum Growth Rate of Diatoms type E at 0°C
3	TcPMxMDI_E	Temperature coefficient for growth of Diatoms type E
4	RcDenSed	Denitrification rate in the sediment
5	RcDenWat	Denitrification rate in the water column
6	VBurDMS1	Burial rate for layer S1

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Algal physiology and WAQ-approach

Growth (primary production):

Growth is equal to maximum growth (PPMax) corrected for temperature and limitations due to nutrients, light and daylength.

$$PProd_i = LimDl_i \times LimNut_i \times LimRad_i \times TFGro_i \times PPMax_i$$

Algal physiology and WAQ-approach

Temperature function:

$$TFGro_i = TCGro_i^{Temp-20}$$

Algal physiology and WAQ-approach

Nutrient limitation:

$$LimNUT_i = \mathrm{Min}\,(LimN_i,\ LimP_i,\ LimSi_i)$$

$$LimN_i = \frac{DIN}{DIN + KmDIN_i}$$

$$LimP_i = \frac{(PO4)}{(PO4) + KmP_i}$$

$$LimSi_i = \frac{(Si)}{(Si) + KmSi_i}$$

$$DIN = (NH4) + \frac{(NO3)}{PrfNH4_i}$$

$$\text{if } KmSi_i = -1 \text{ then } LimSi_i = 1.0$$

Algal physiology and WAQ-approach

Respiration has 2 components:

maintenance respiration

growth respiration

$$RcResp_i = PProd_i \times GResp_i + MResp_i \times TFMrt_i \times (1 - GResp_i)$$

Algal physiology and WAQ-approach

Mortality:

Constant mortality rate (1/day), only corrected for temperature.

$$RcMrt_i = Mort_i \times TFMrt$$

With temperature function:

$$TFMrt_i = TCDeC_i^{Temp-20}$$

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Enabling Delta Life

Light and Extinction

WAQ_Algae_03

Light and extinction

Extinction with depth

Extinction by different components

- → inorganic material
- → organic material
- → algae
- → background (water and dissolved substances)

Daylight limitation

(Spectral distribution)