

13. 12. 2021.

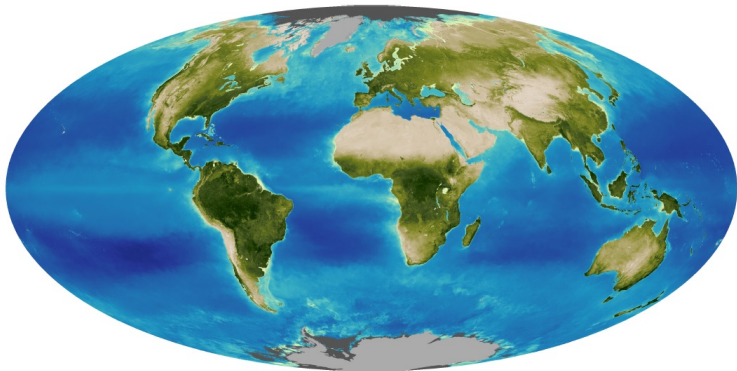
SHORT COURSE ON MARINE DATA LITERACY

MARINE PRIMARY PRODUCTION

ŽARKO KOVAČ

DEPARTMENT OF PHYSICS, FACULTY OF SCIENCE, UNIVERSITY OF SPLIT

Where are we now?

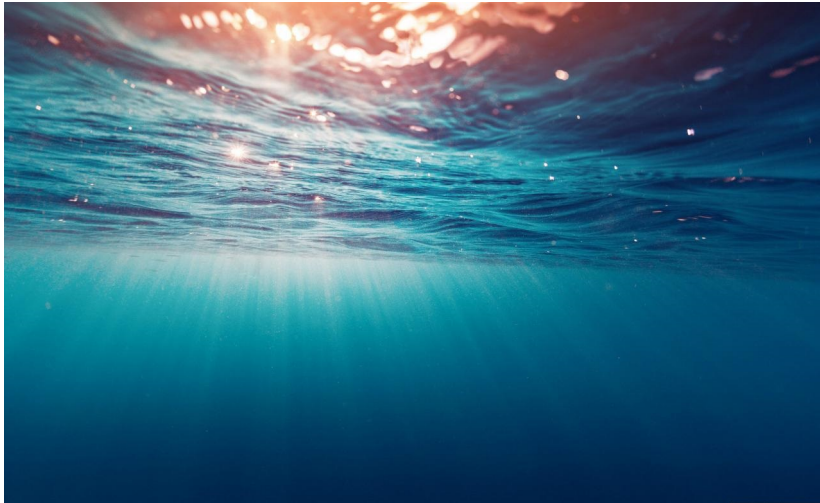


Anthropogenic carbon emissions per year 10 Gt C
Carbon assimilated by the biosphere per year 100 Gt C
Carbon assimilated by phytoplankton 50% of total
Phytoplankton biomass 1% of total land biomass

Think globally, model locally :)



What happens below the surface?



Vertical structure

Primary production

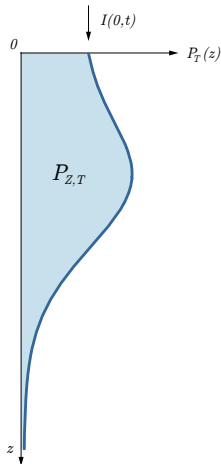
$$P(z, t) \quad [\text{mg C m}^{-3} \text{ h}^{-1}]$$

Daily production

$$P_T(z) \quad [\text{mg C m}^{-3}]$$

Watercolumn production

$$P_{Z,T} \quad [\text{mg C m}^{-2}]$$



Mathematical formalism

Primary production

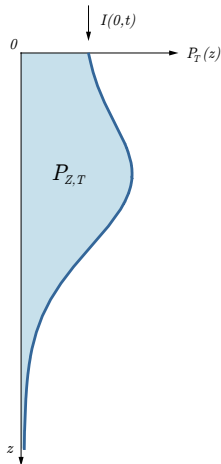
$$P(z, t) = B(z) p^B(I(z, t))$$

Daily production

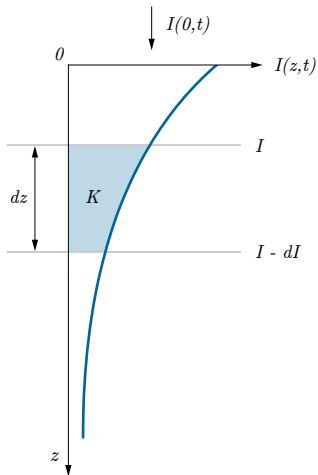
$$P_T(z) = \int_0^D B(z) p^B(I(z, t)) dt$$

Watercolumn production

$$P_{Z,T} = \int_0^\infty \int_0^D B(z) p^B(I(z, t)) dt dz$$



Underwater light field



Surface irradiance

$$I(0) = I_0$$

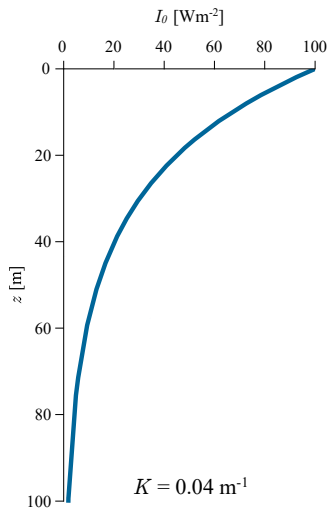
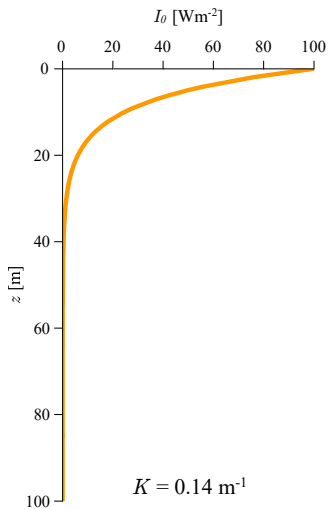
Beer-Lambert law

$$\frac{\partial I}{\partial z} = -KI$$

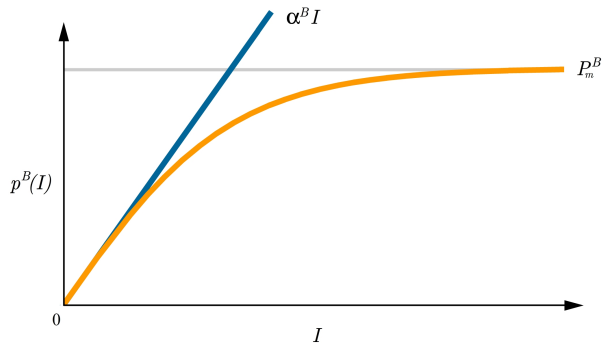
Irradiance at depth

$$I(z) = I_0 \exp(-Kz)$$

Example

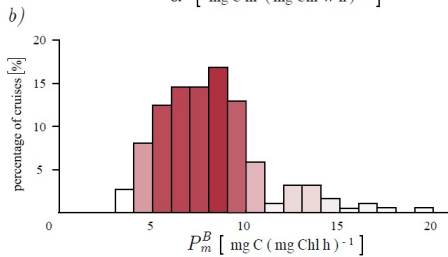
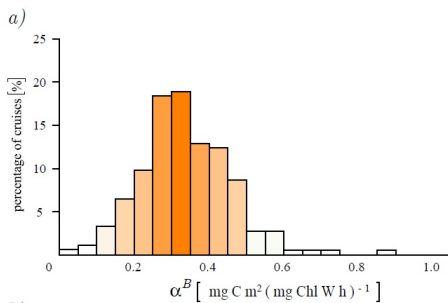


Photosynthesis irradiance function

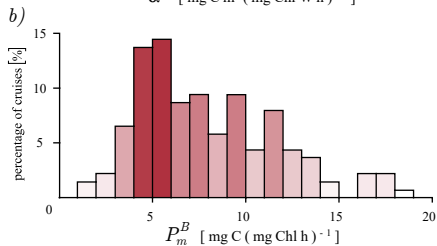
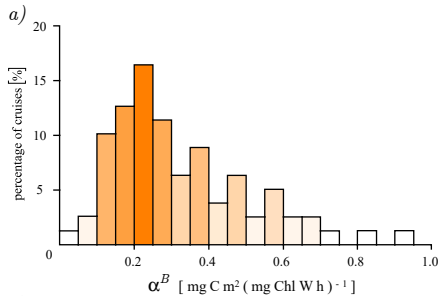


$$p^B(I) = P_m^B \left(1 - \exp(-\alpha^B I / P_m^B) \right)$$

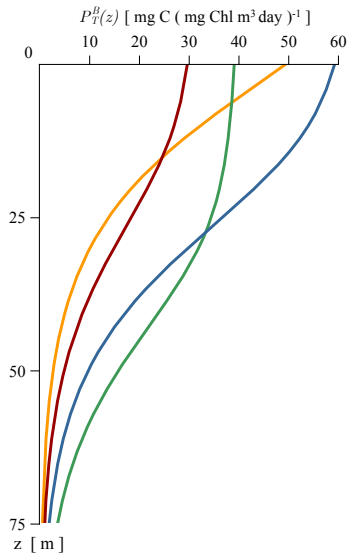
Parameters at Hawaii



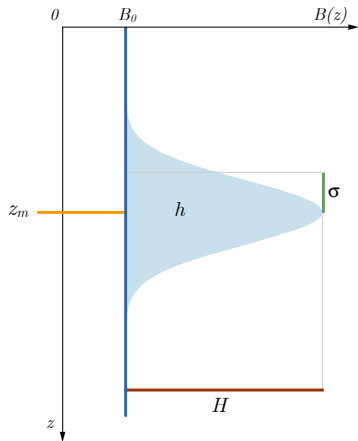
Parameters at Bermuda



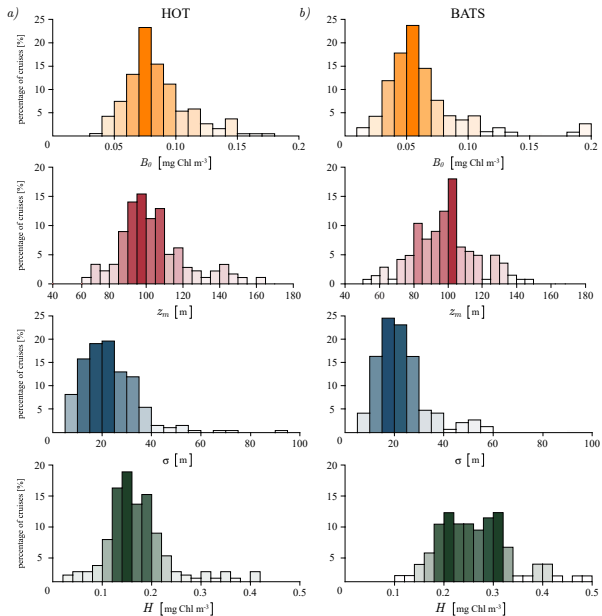
Example



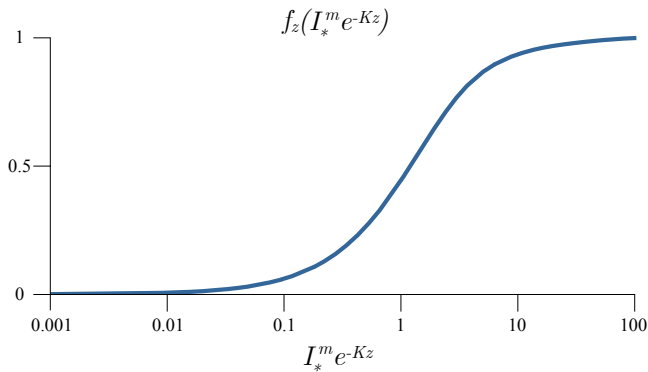
Biomass profile



$$B(z) = B_0 + \frac{h}{\sigma\sqrt{2\pi}} \exp\left(-\frac{(z - z_m)^2}{2\sigma^2}\right)$$



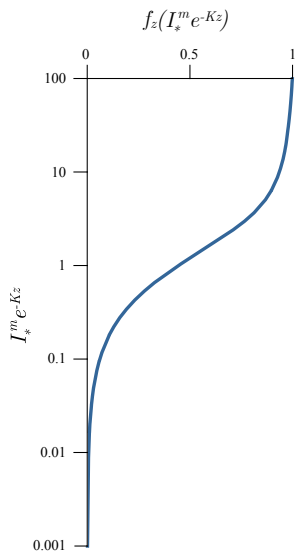
Canonical solution for daily production at depth



$$P_T(z) = B(z)P_m^B D f_z(I_m^*)$$

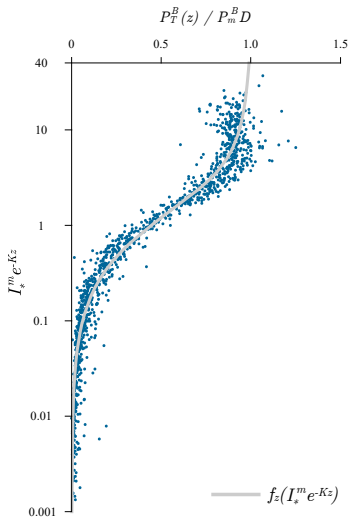
(Kovač et al., 2016)

Daily production profile

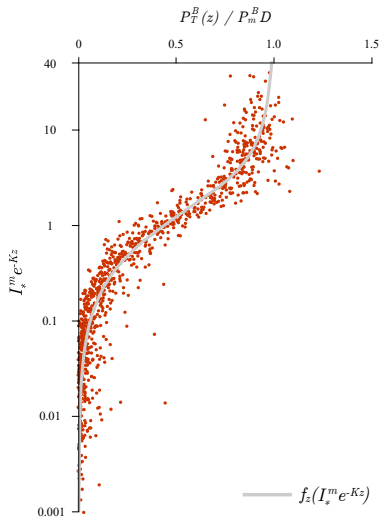


$$P_T(z) = B(z) P_m^B D f_z \left(I_*^m e^{-Kz} \right)$$

Model versus data for production at depth

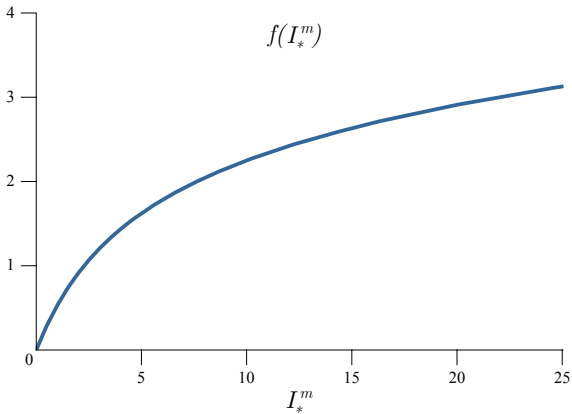


Hawaii R^2 **0.97**



Bermuda R^2 **0.95**

Canonical solution for daily watercolumn production

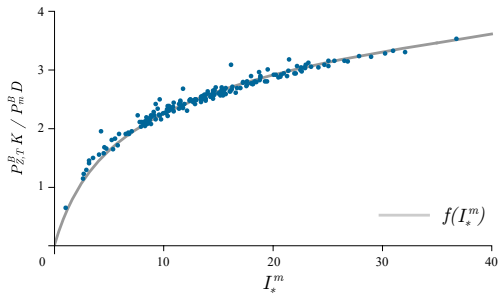


$$P_{Z,T} = \frac{BP_m^B D}{K} f(I_*^m)$$

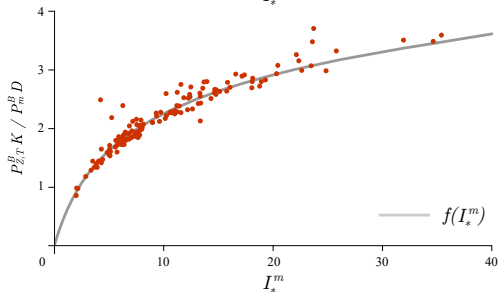
$$I_*^m = \frac{\alpha^B I_0^m}{P_m^B}$$

(Platt et al., 1990)

Model versus data for watercolumn production



Hawaii R^2 **0.99**



Bermuda R^2 **0.97**

(Kovač et al., 2016, 2018)

Thank you :)