Presentations: Getting Carbon Estimates from Fish Biomass

Bioenergetics and Aquaculture

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Today

- Classical bioenergetics models
  - Wisconsin
  - Dynamic energy Budget (DEB)

- Aquaculture impacts
  - Waste products
  - Effects on local benthic areas
  - Export downstream

Taylor & Francis
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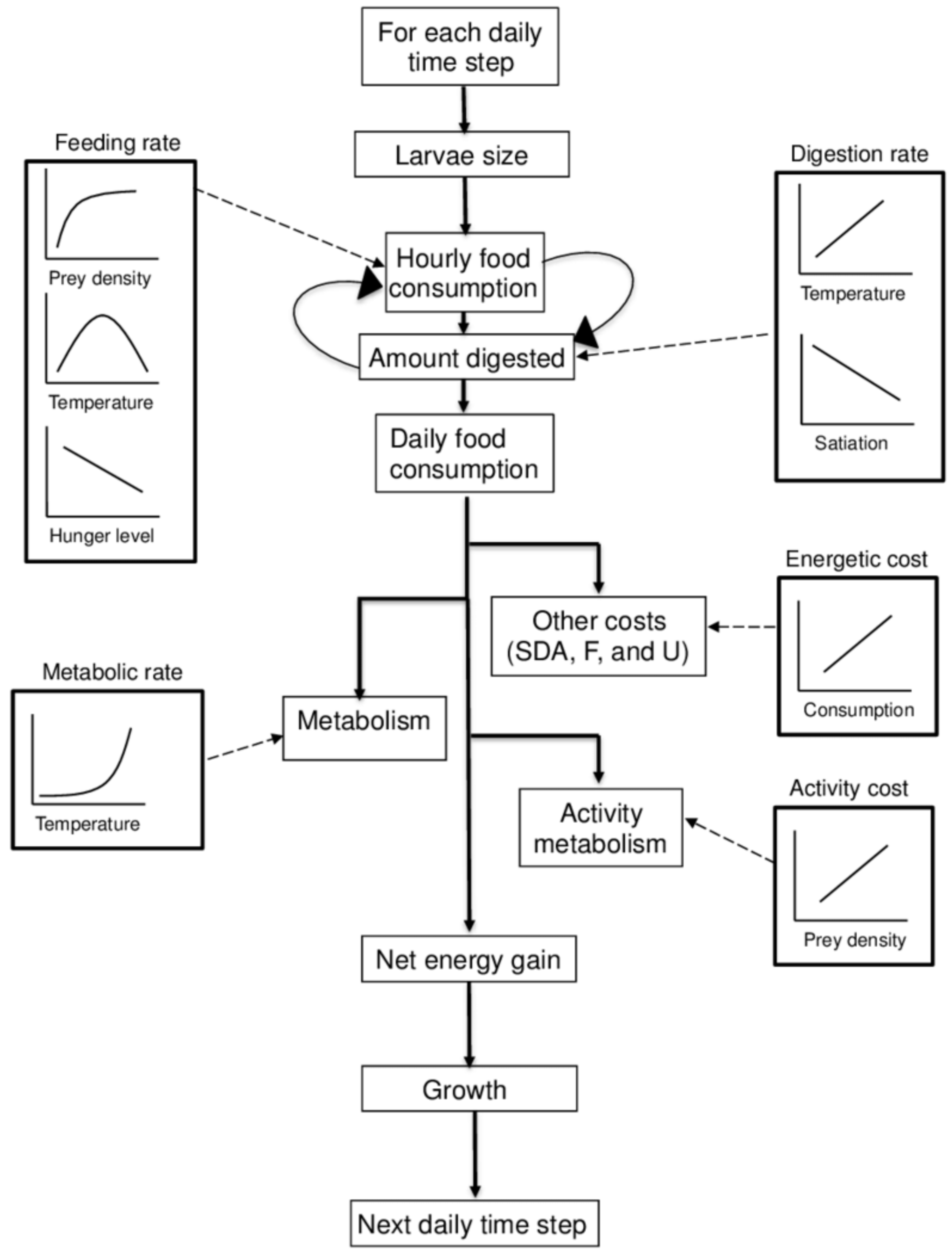
Fisheries

ISSN: 0363-2415 (Print) 1548-8446 (Online) Journal homepage: http://www.tandfonline.com/loi/ufsh20

Fish Bioenergetics 4.0: An R-Based Modeling Application

David Deslauriers, Steven R. Chipps, James E. Breck, James A. Rice & Charles P. Madenjian



Deslauriers, David. (2015). Development and application of a spatially-explicit model for estimating growth of age-0 Pallid Sturgeon in the Missouri River. Dissertation, South Dakota State University.

Bioenegetics Model

$$\frac{dW}{W \cdot \ dt} = [C - (R + SDA + F + E + P)]$$

W:wet weight(g), t:time(day),
C:consumption (gprey/gfish/day),
R:respiration or losses through metabolism (gprey/gfish/day),
SDA: specific dynamic action or losses due to energy costs of digesting food (gprey/gfish/day),
F:egestion or losses due to feces (gprey/gfish/dday),
E:excretion or losses of nitrogenous excretory wastes (gprey/gfish/dday),
P:egg production or losses due to reproduction (gprey/gfish/d)

★**Foods of saury are ＺＳ，ＺＬ，ＺＰ with selective function**

(VENFISH, 2002 PICES MODEL/REX TASK TEAM, 伊藤ら2002)

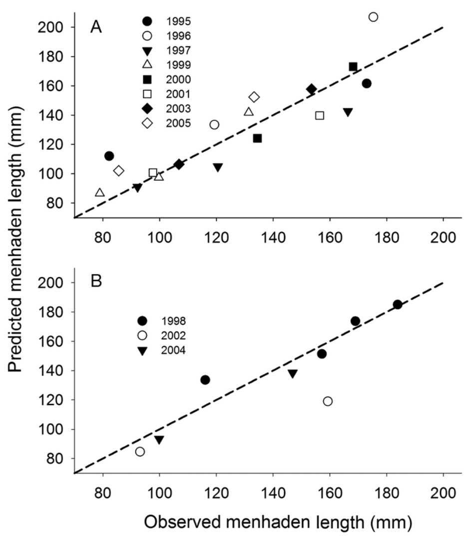
$$\frac{dW_i}{dt} = [C_i - (R_i + S_i + EG_i + EX_i)]\frac{CAL_z}{CAL_f}W_i - EGG_i\,W_i$$

$$C_{max} = a_C W_i^{-b_C} f_C(T)$$

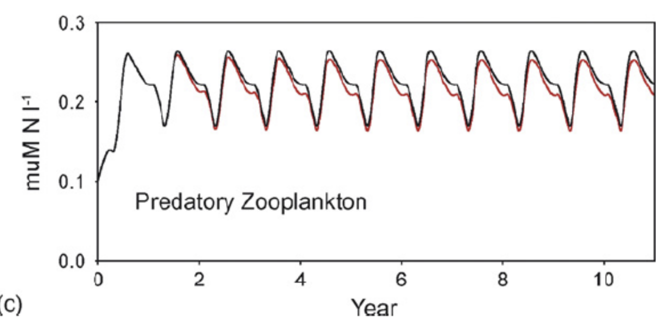
C = p-value x Cmax

$$C_i = \sum_{j=1}^{3} C_{ij},$$

$$C_{ij} = \frac{C_{max}(PD_{ij}\upsilon_{ij}/K_{ij})}{1 + \sum_{k=1}^{3}(PD_{ik}\upsilon_{ik}/K_{ik})}$$

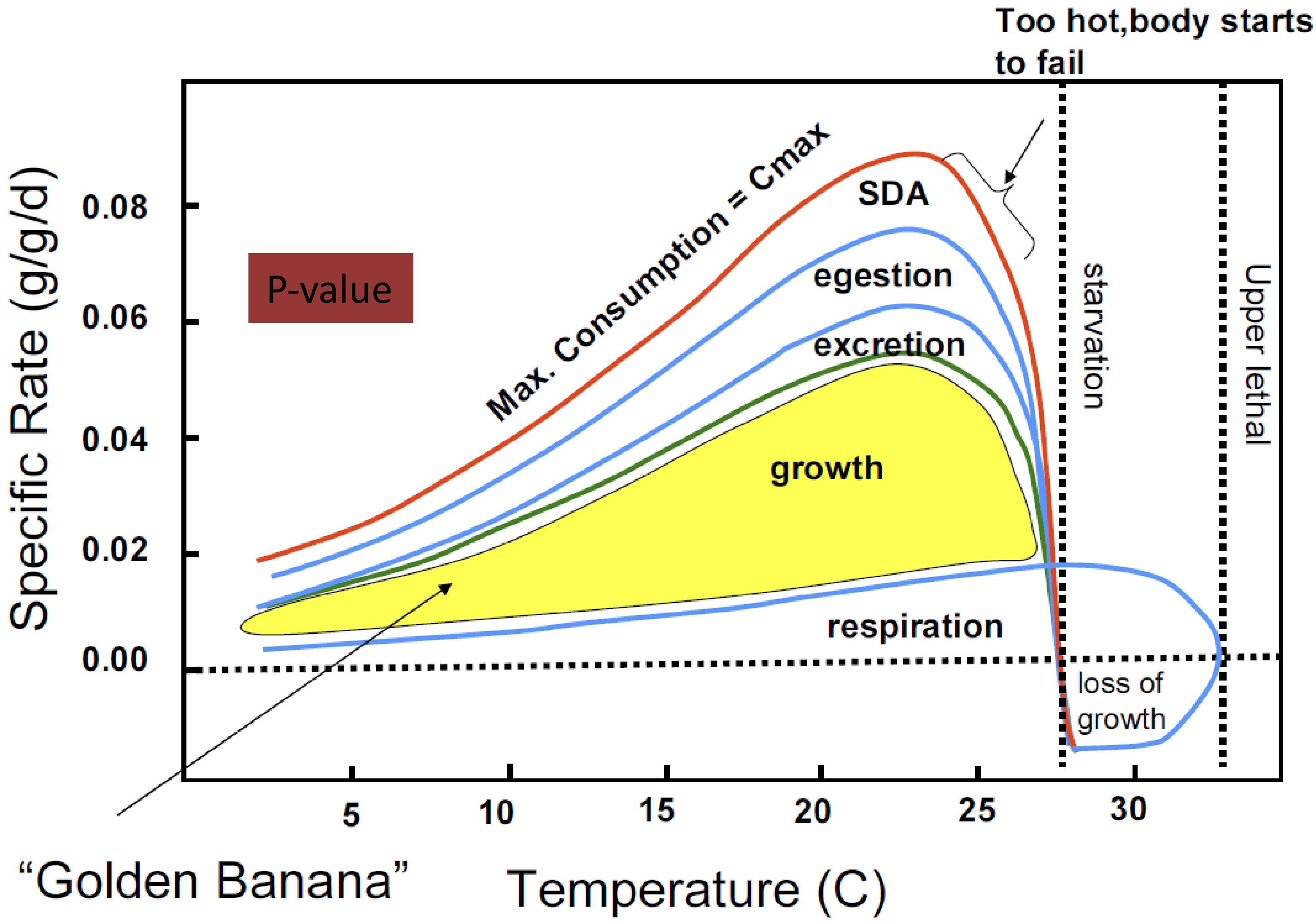


Annis et al. 2011. MEPS 437:253-267.

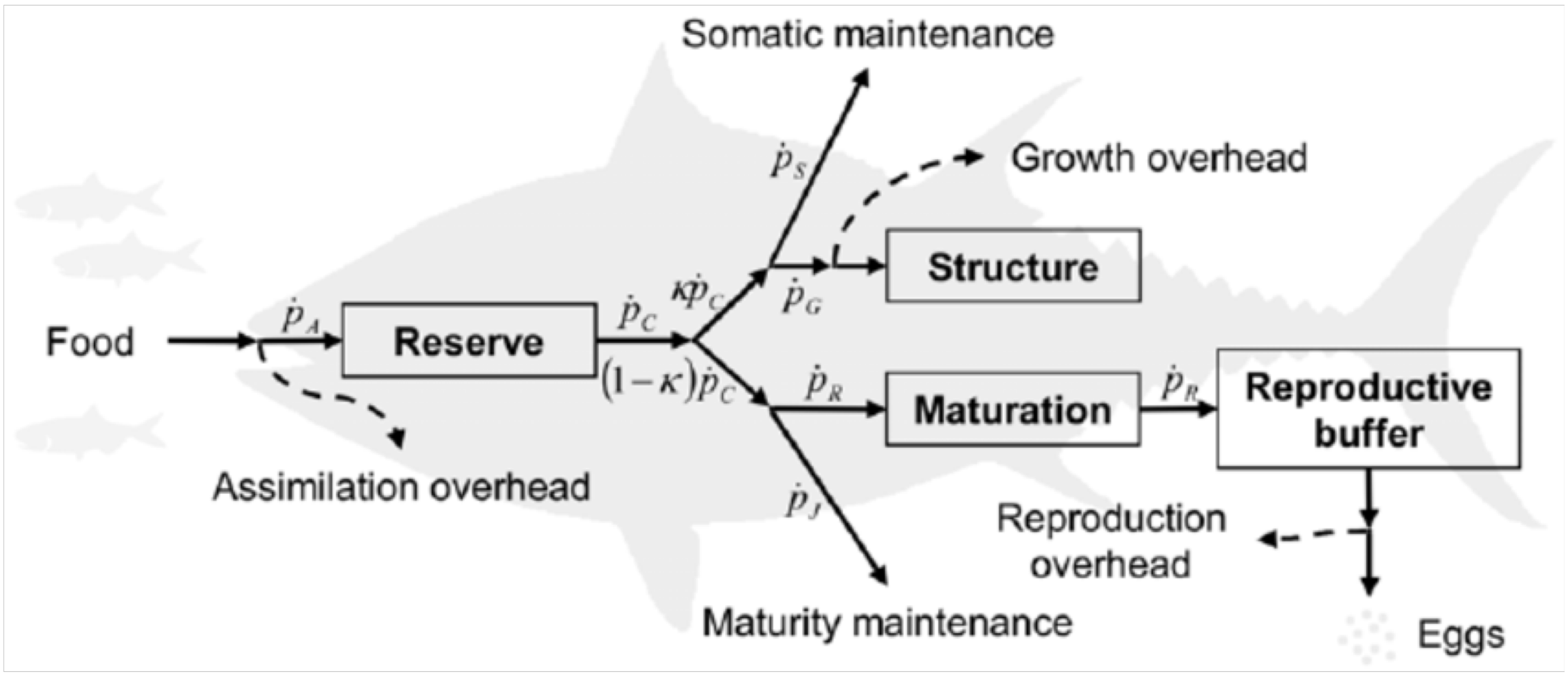


(c)

All processes are temp. and size dependent



DEB



Somatic maintenance
$\dot{p}_S$
Growth overhead
Structure
$\kappa\dot{p}_C$
$\dot{p}_G$
Food
$\dot{p}_A$
Reserve
$\dot{p}_C$
$(1-\kappa)\dot{p}_C$
$\dot{p}_R$
Maturation
$\dot{p}_R$
Reproductive buffer
Assimilation overhead
$\dot{p}_J$
Reproduction overhead
Maturity maintenance
Eggs

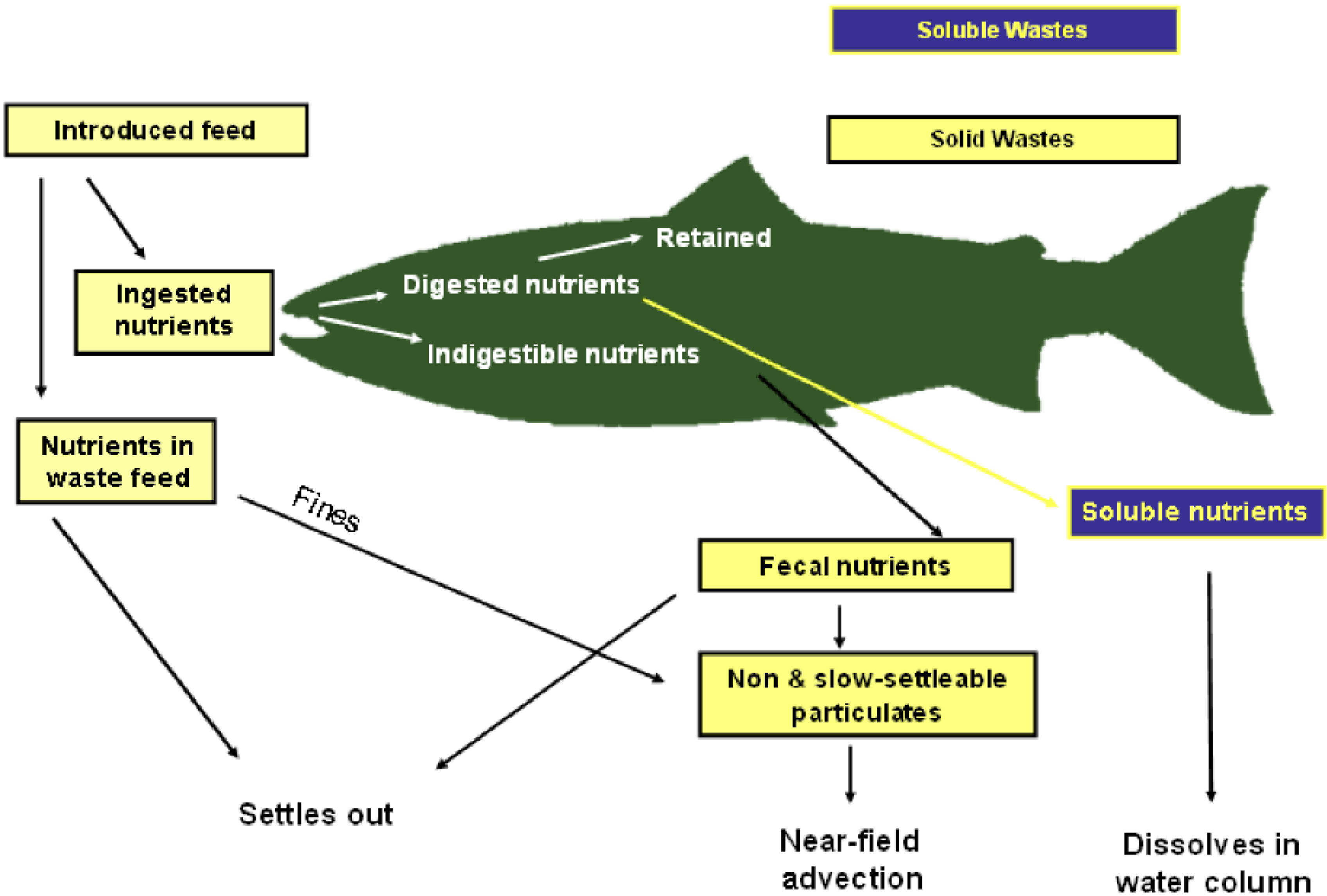


Figure 1: The flow and fate of nutrients in a cage aquaculture system

Aquaculture

Aquaculture 214 (2002) 211–239

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DEPOMOD—modelling the deposition and biological effects of waste solids from marine cage farms

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Received 28 February 2001; received in revised form 23 November 2001; accepted 15 July 2002

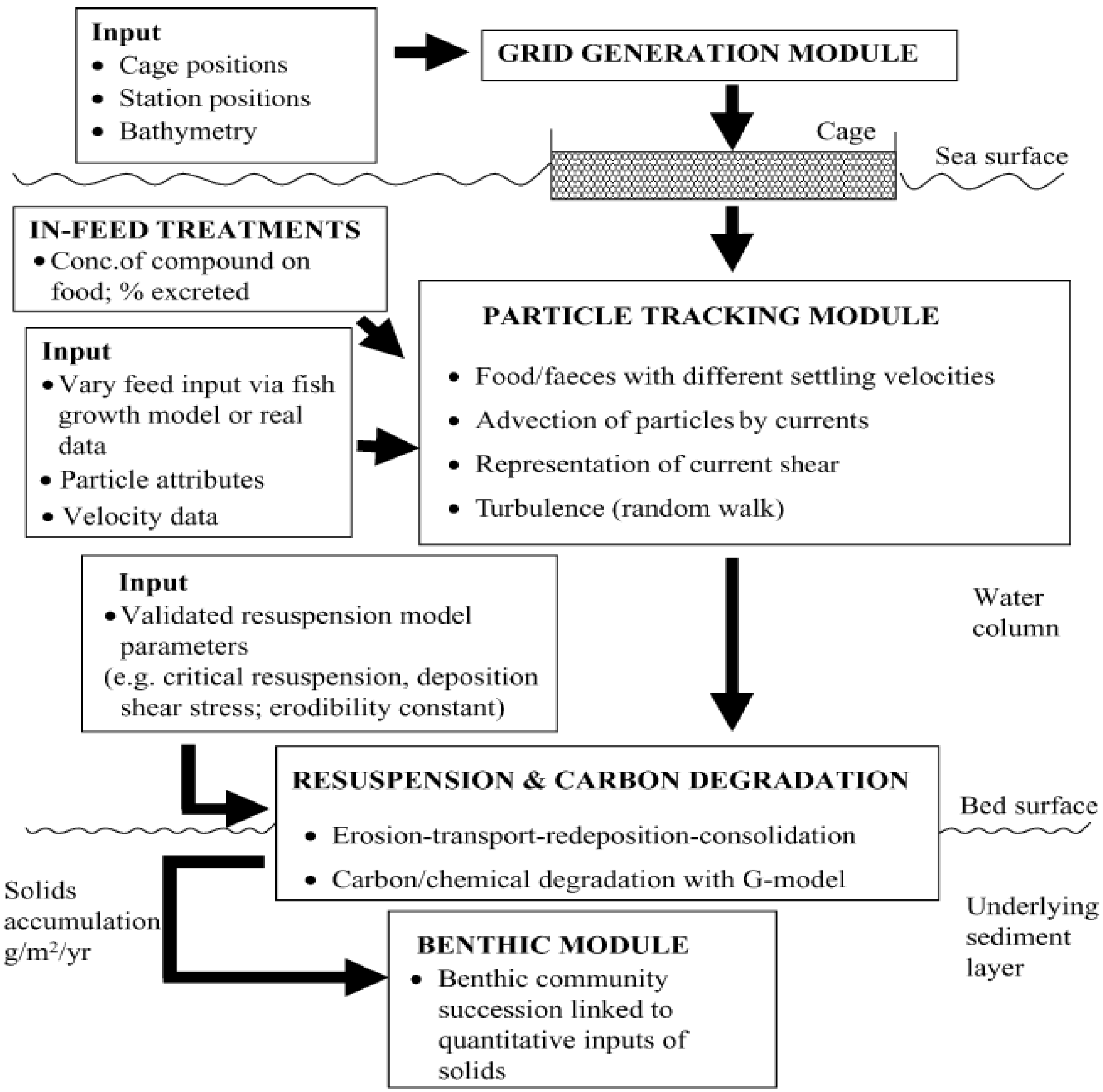


Fig. 1. Integration of the DEPOMOD modules and associated input data used for modelling benthic impacts arising from marine cage fish farms.

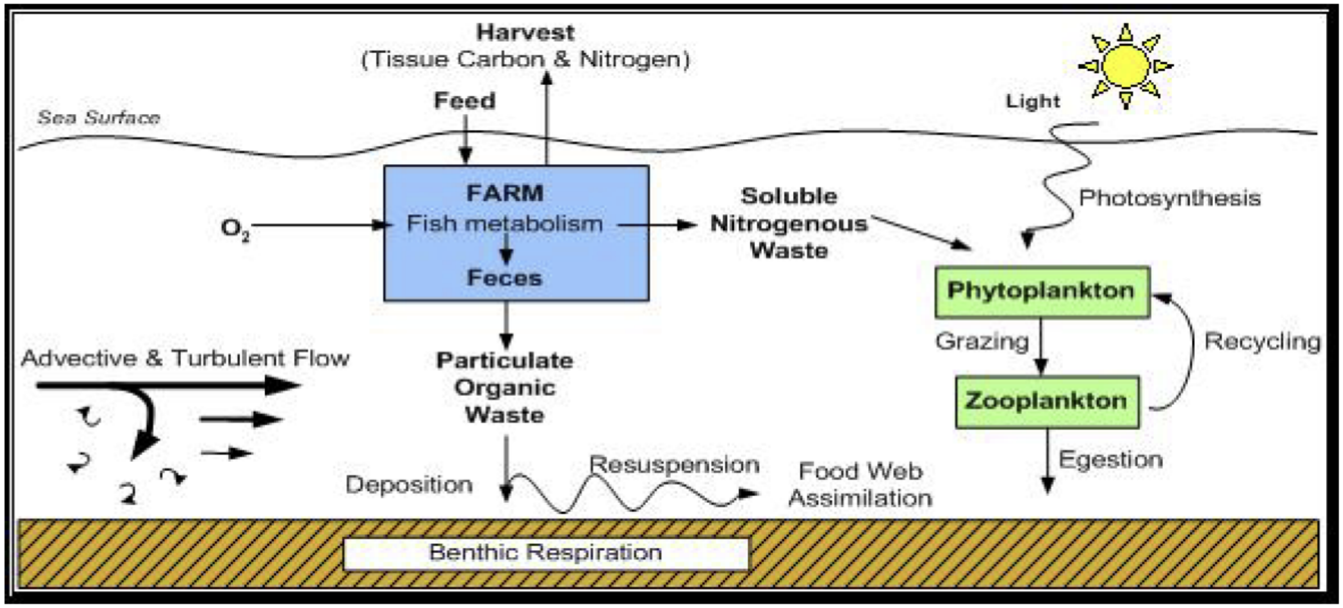


Figure 3. Components and transformations of water column and benthic submodels.

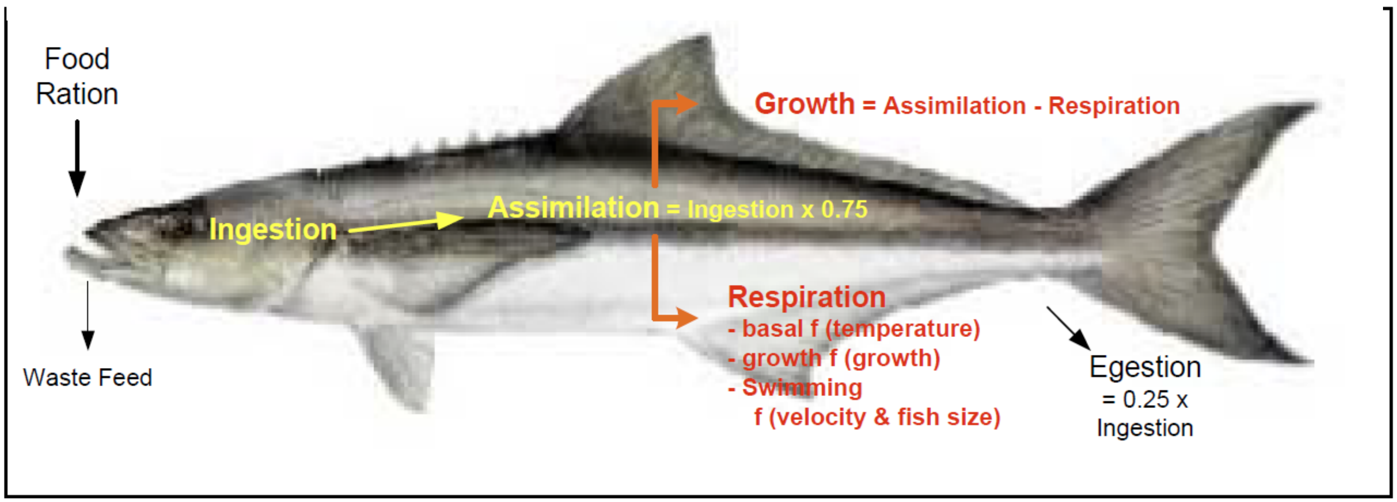


Figure 4. Generalized fish metabolic processes described by the model.

Rensel, J.E., Kiefer, D.A. and F. O'Brien. 2006. Modeling Water Column and Benthic Effects of Fish Mariculture of Cobia (Rachycentron canadum) in Puerto Rico: Cobia AquaModel. Prepared by Systems Science Applications, Inc., Los Angeles, Ca. for the NOAA, Washington D.C. 60 pp.

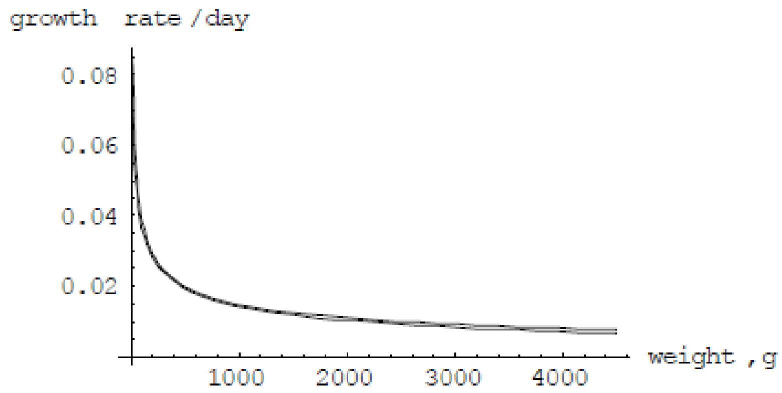


Figure 5. The von Bertalanffy growth curve for cobia tuned to fit selected data from growth in fish farms.

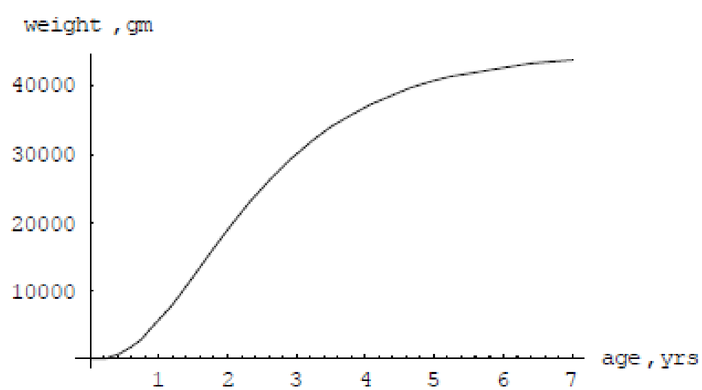


Figure 6. The specific growth rate of cobia as a function of weight at age.

Two curves are plotted, one is calculated from our cobia model the other is derived directly from the von Bertalanffy growth curve shown in the figure above.

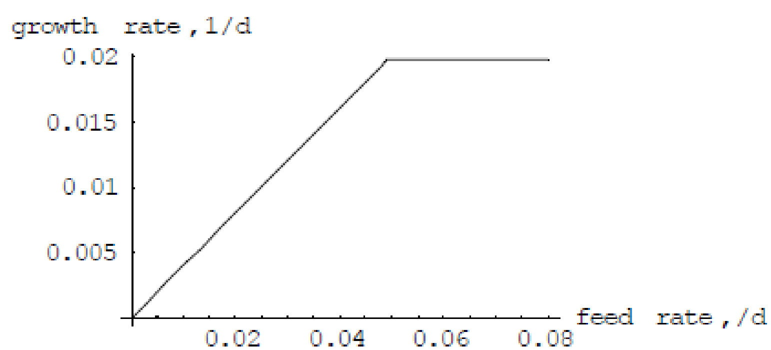
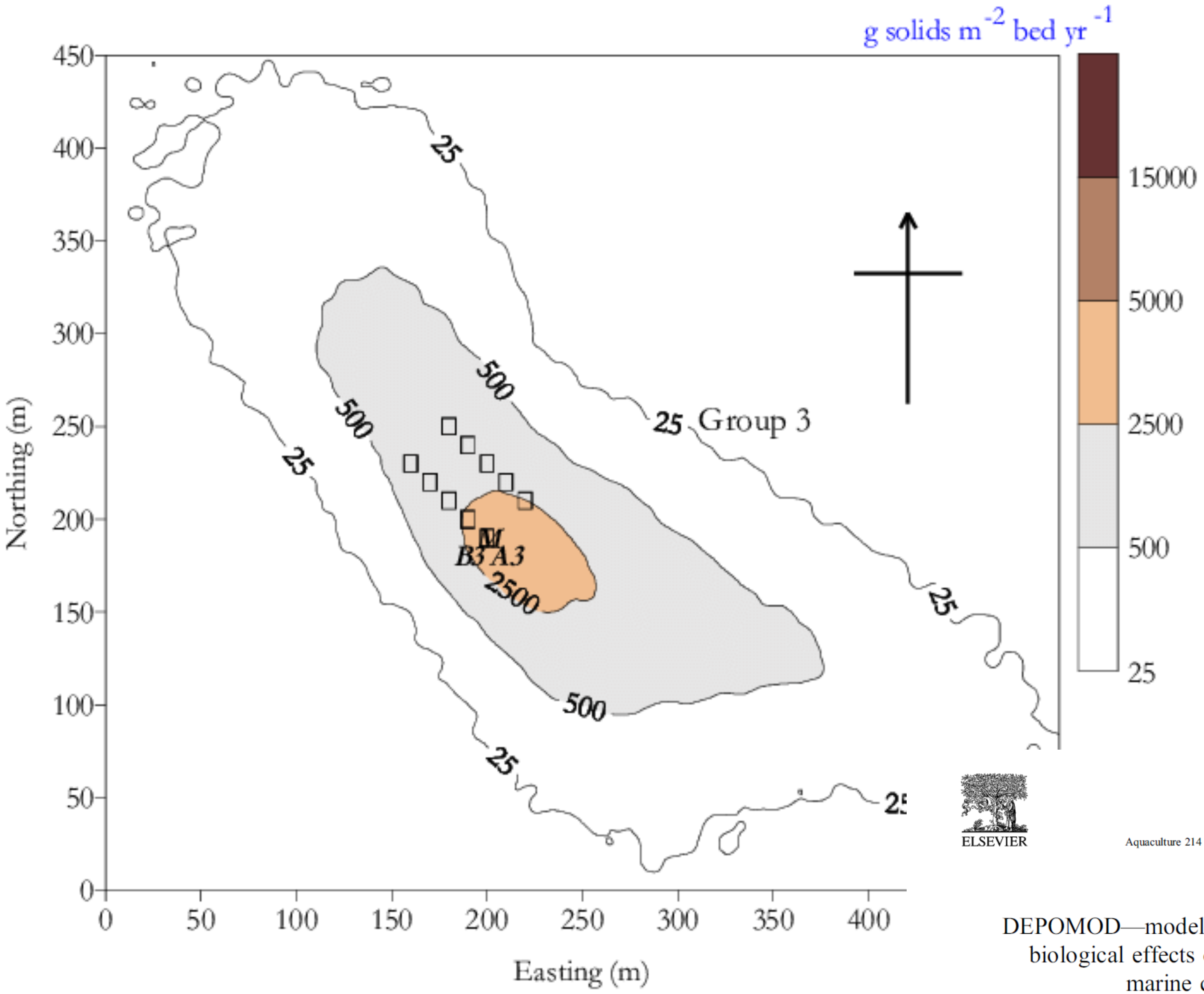


Figure 7. The calculated specific growth rate of cobia as a function of specific feed rate.

Temp. 28°C, weigh 500g, good growth efficiency exhibited.

Rensel et al. 2006. "Cobia AquaModel"



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DEPOMOD—modelling the deposition and biological effects of waste solids from marine cage farms

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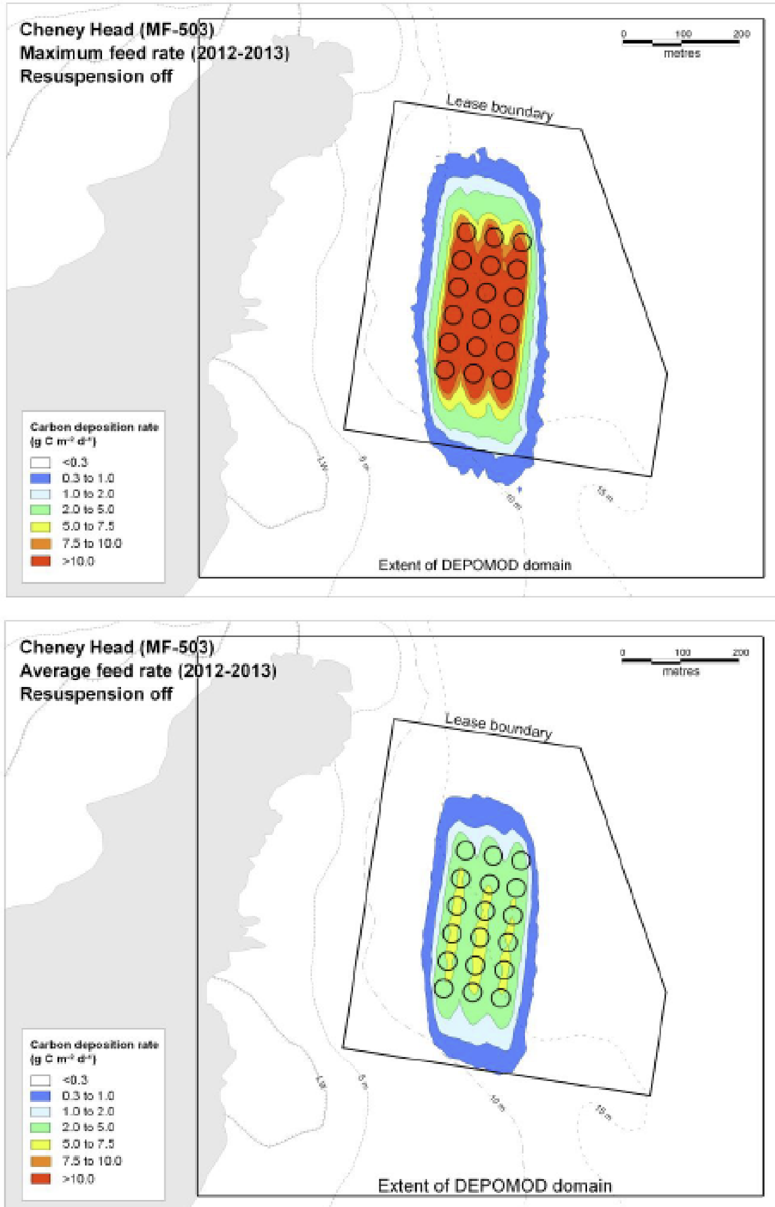

*Figure 2.4. Contour plot of DEPOMOD predicted carbon deposition rates at the Cheney Head salmon farm (MF-503), with a total of 500,000 fish in 18 cages, using the proposed **maximum** feed rate (902 kg d^{-1} per cage; top) and the proposed **average** feed rate (255 kg d^{-1} per cage; bottom), with resuspension off. With resuspension on, there was no waste deposition predicted within the model domain at both feed rates.*

DFO. 2013. DEPOMOD Predictions for an Aquaculture Site at Cheney Head, New Brunswick. DFO Can. Sci. Advis. Sec. Sci. Resp. 2012/035

Options

- Biomass of species or types
  - Data or model -generated
- Seasonal?
- Major productivity areas - rest is not desert
- Simple efficiencies or growth or bioenergetics
- Composition?
- Fluxes?

Data Sources

- Global models of biomass
- FishBase
- Many bioenergetics and DEB as well as efficiences
- Assign by:
  - Species
  - Life history
  - Size
  - Life style