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Assumptions and model structure for the growth and survival of the holopelagic brown macroalga *Sargassum* spp. based on DEB (Dynamic Energy Budget) theory

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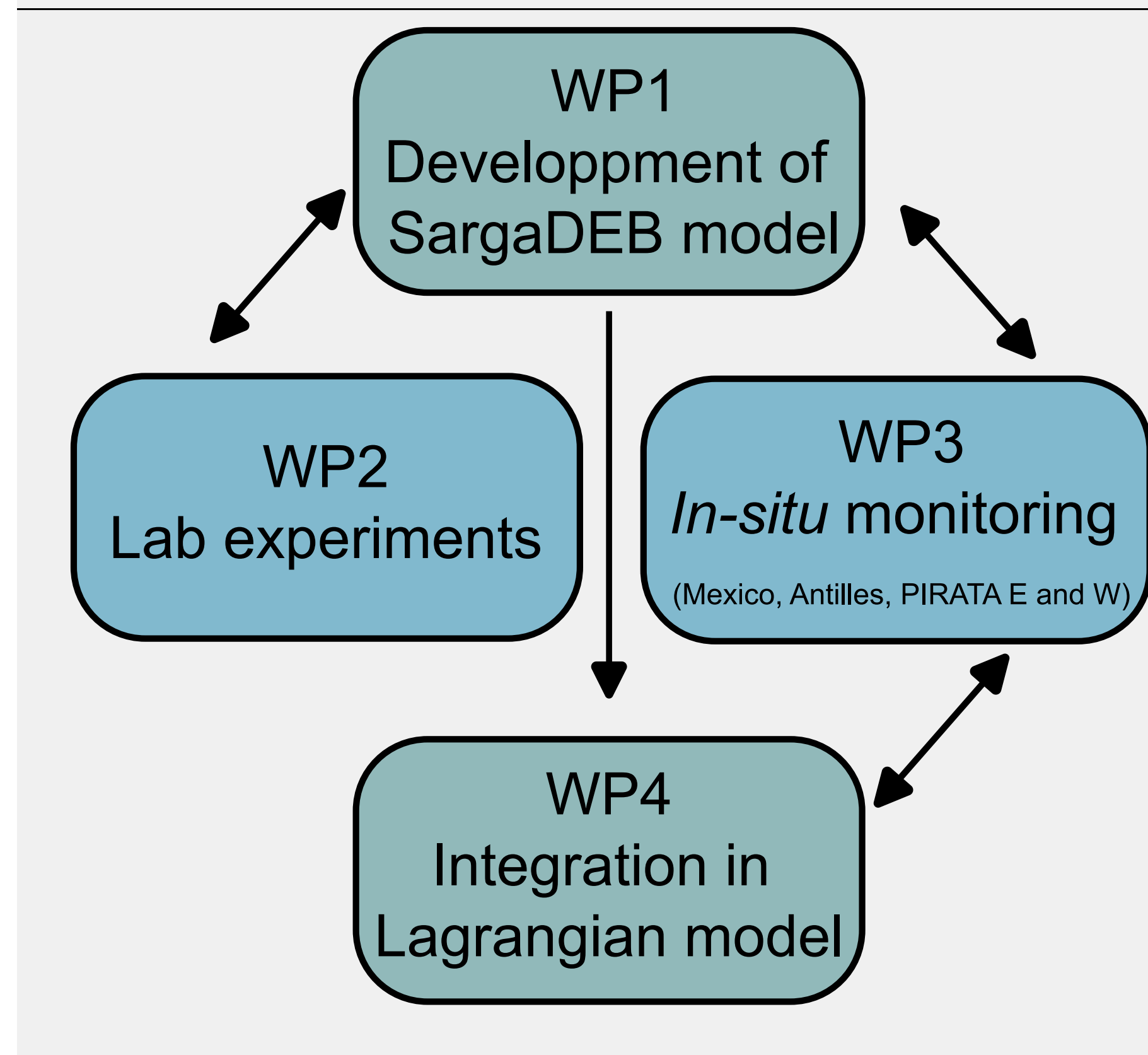
PROJECT CONTEXT

Massive strandings of holopelagic *Sargassum* spp. have been observed since 2011 in the east and west coasts of the tropical North Atlantic causing ecological, socio-economic and health problems.

Several models have been developed to simulate *Sargassum* drift [9, 2], few studies have integrated physiology into a Lagrangian model to study *Sargassum* growth. Moreover, few have made a difference between morphotypes [3, 5]. Holopelagic *Sargassum* has three morphotypes *Sargassum natans* I, *S. natans* VIII and *S. fluitans* III which strand on the coasts with different proportions depending on the year [1, 4]. However, there is no study about physiological characteristics of each morphotype explaining these differences.

To fill these gaps a synergetic approach between a modeling PhD thesis in LEMAR and MARBEC and an experimentation PhD thesis funded by the IRD in Mexico, will be done framed in the BIOMAS project (BIOenergetic Modeling Approach for *Sargassum* Dynamics).

OBJECTIVES OF THE BIOMAS PROJECT



For the first part of the modeling thesis we will work between WP1 and WP2 to:

1. Build a mechanistic model of holopelagic *Sargassum* growth based on DEB theory and current knowledge.
2. Identify and quantify key parameters of the three *Sargassum* morphotypes to calibrate model with laboratory controlled conditions.

MODEL ASSUMPTIONS AND STRUCTURE

DEB theory describes at the individual level, the energy and mass flow within the organism and the exchanges between the organisms and its surroundings [6]. This theory is based on general concepts on physiology and has been applied to many different types of organisms.

Two-nutrient DEB models have been developed for other macroalgae like *Ulva lactuca* [7] and *Saccharina latissima* [10] to study growth and nutrient dynamics.

Considering holopelagic *Sargassum* knowledge and previous models, we'll include phosphorus and exclude sexual reproduction.

Model will be constructed to simulate growth and survival based on nutrient concentrations, temperature and irradiance. Model will also test for starvation conditions, important to understand *Sargassum*'s seasonal dynamics.

EXAMPLE OF SIMULATIONS

Numerical experiments (Fig. 1) that can be done using the SargaDEB model are:

- N and P uptake rate based on different nutrient concentration
- Oxygen production rate as function of irradiance
- Length of *Sargassum* morphotypes
- N:C:P ratio under starvation conditions
- Rejection flow of each nutrient

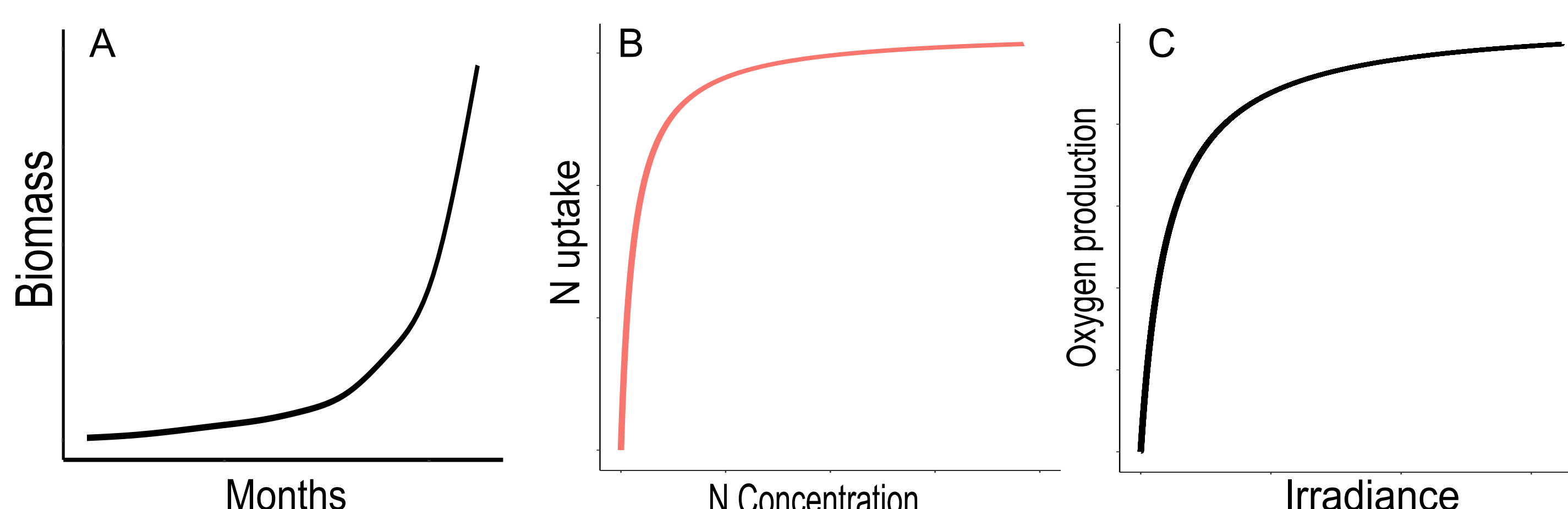


Figure 1. Simulations of A) Biomass evolution B) N uptake and C) Oxygen production. Adaptation of [10] GitHub code based on algae models previously developed [7, 10].

MODEL CALIBRATION AND VALIDATION

To identify key parameters and to design adequate protocols for parameter calibration, the experimentation protocol will be defined jointly with the PhD Mexican partner in order to identify forcing variables/culture conditions to obtain the same observable/response variables (Fig. 2). Afterwards, model parameters for each of *Sargassum* morphotypes will be calibrated using the experimental data sets. Finally, the model will be validated using independent data sets.

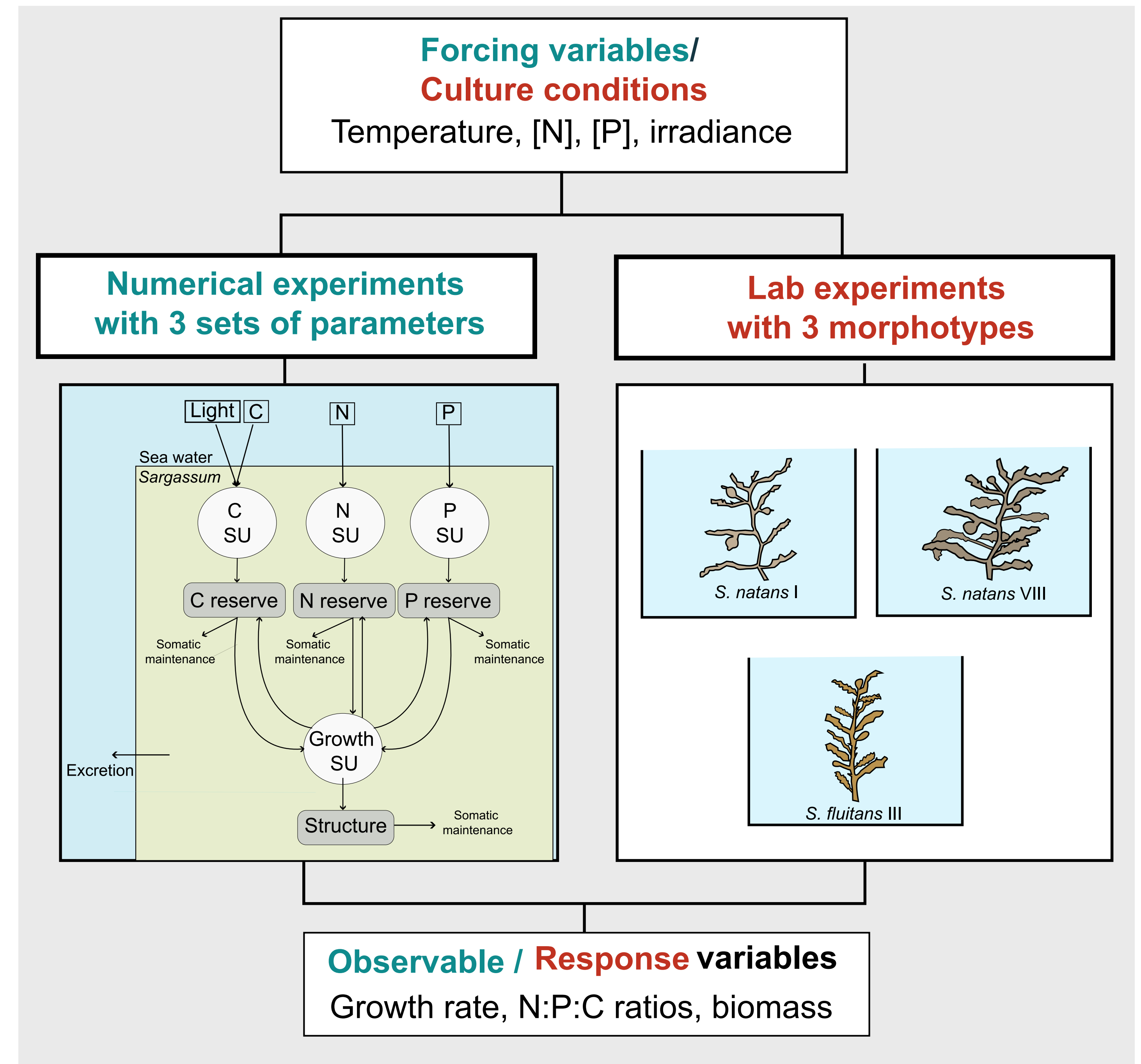


Figure 2. Numerical experiments with the SargaDEB model and lab experiments (Mexican partners) to estimate DEB parameter sets of the three *Sargassum* morphotypes.

INTEGRATION WITH DRIFT MODEL

The DEB model will then be integrated into Ichthyop (WP4), a Lagrangian drift model forced by realistic physical-biogeochimical simulations and advection processes [8]. Using the set of DEB parameters previously estimated for each morphotype (WP1 and WP2), we will be able to simulate *Sargassum* growth and survival at basin scale and seasonal temporal scales. The integrated model will be validated using *in-situ* monitoring of *Sargassum*, which will be possible thanks to the collaboration with Brazilian, Mexican and African partners (WP3).

CONCLUSIONS

Through this model-experimentation approach, the BIOMAS project aims to assess the specific physiological traits of each holopelagic *Sargassum* morphotype, allowing the integration of the physiological model into the drift model for more accurate forecasting of *Sargassum* spp proliferation and strandings across different seasons and regions in the Atlantic Ocean.

ACKNOWLEDGMENTS

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