A simple NPZD model for Llanquihue Lake

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Abstract

In the present study, a mathematical model (NPZD) based on the four compartments Nutrient (N), Phytoplankton (P), Zooplankton (Z) and Detritus (D), is proposed for understanding the ecology of shallow coastal lagoons. Model is simulated for the two cases of detritus link with the system: i) through remineralization and ii) through remineralization and palatability of detritus to zooplankton.

Introduction

A biogeochemical model is a simplified and mathematical representation of the biological, geological, and chemical processes that occur in ecosystems. These models are used to understand and simulate the flows of energy, nutrients, and chemical elements through natural systems such as oceans, forests, soils, and bodies of water. Biogeochemical models integrate information about biogeochemical cycles, which include processes like photosynthesis, decomposition, respiration, nitrogen fixation, nutrient leaching, and atmospheric deposition.

These models take into account the interactions between different components of the system, such as plants, animals, microorganisms, soils, and the atmosphere. Biogeochemical models are powerful tools for predicting the effects of environmental change, such as climate change, pollution, and deforestation, on biogeochemical cycles and ecosystem health. They are also used to assess the effectiveness of management and conservation strategies and to inform decision-making in natural resource management.

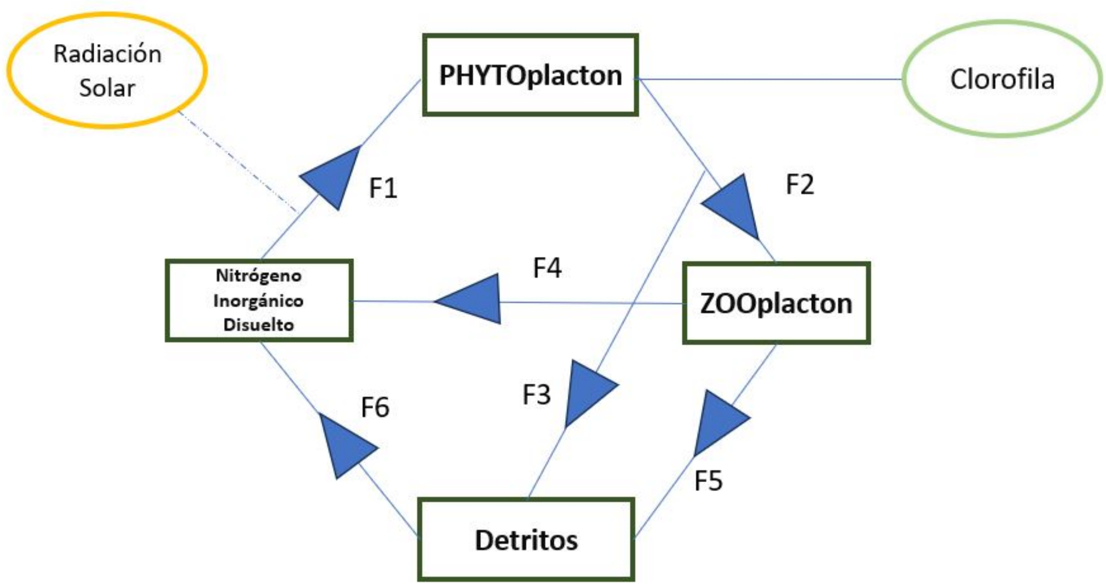
Biological models have been widely used to understand the dynamics and interactions in pelagic ecosystems. Among them, compartmental models have been especially relevant by grouping entire populations into individual compartments that interact with each other. The complexity of these models varies depending on the included state variables and the rules governing their interaction. One known model in this context is the model proposed by Fasham et al. (1990), which includes seven compartments: phytoplankton, zooplankton, bacteria, nitrate, ammonium, dissolved organic nitrogen, and detritus. However, one of the simplest and most widely used biological models is the NPZ model developed by Franks et al. (1986), which considers only three compartments: phytoplankton, zooplankton, and dissolved nutrients.

The NPZ model captures the fundamental processes governing the growth and interactions between these key compartments. It considers variables such as nutrient availability, grazing pressure, and phytoplankton growth rates, providing a simplified yet valuable representation of pelagic ecosystem dynamics. This model has been adapted and applied in various marine environments, providing crucial insights into the functioning of planktonic communities and their responses to environmental changes.

In conclusion, biological models like the NPZ model play a crucial role in our understanding of the complex dynamics and interactions in pelagic ecosystems. While more complex models encompass multiple compartments and variables, the NPZ model provides an effective and simplified representation of essential components in these ecosystems. These models are valuable tools for advancing our knowledge and contributing to the conservation and management of marine habitats.

2. Model Formulation

A mathematical model (NPZD) based on four compartments (Nutrient (N), Phytoplankton (P), Zooplankton (Z), and Detritus (D)) is proposed to understand the ecology of shallow coastal zones and lagoons. The interactions between the compartments are described in Figure 1.



The arrows indicate the flow of matter between different compartments. The equations of the model are as follows:

$dN/dt = -(a(t)NP)/(Kn + N) + rP + D + [m/H(t)]N1(t) + (Q/V)N2(t)$

$dP/dt = (a(t)NP/Kn + N) - rP - [p1P/A][c(A - A0)Z/Kz + A - A0] - [uP/K + P]P$

$dZ/dt = [(eC(A - A0)Z)/Kz + A - A0] - g * Z$

$dD/dt = [uP/K + P]P - oD + [p1P/A][((1 - e)c(A - A0)Z)/Kz + A - A0] - [p2D/A][eC(A - A0)Z/Kz + A - A0]$

All parameters, along with their units and ranges, are provided in Table 1. The units for N, P, Z, and D are µg/l, and the unit of time is in days. The parameterization used to select the terms in equations (1) - (4) is explained in the sections…..

PARAMETERS	**Value for numerical experimients**	**Value assigned to Site 1**	**Value Assigned to Site 2**	**Value Assigned to Site 3**
maxUptake	1.0			
ksPAR	140			
ksDIN	1.0			
maxGrazing	1.0			
ksPHYTO	1.0			
pFaeces	0.3			
excretionRate	0.1			
mortalityRate	0.4			
mineralizationRate	0.05			
depth	10			
K	20			
u	0.028			

Table 1: Parameters values used in the model

3. RESULTs

4. CONCLUSIONs

5. BIBLIOGRAFIA

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2016; Lai et al. 2010; Kloosterman, Campbell, and Poulin 2016; Jiang, Schofield, and Falkowski 2005; Giricheva 2019; Gentleman and Neuheimer 2008; Franks 2002; A. M. Edwards 2001; C. A. Edwards, Powell, and Batchelder 2000; Daewel et al. 2014; Carlotti, Giske, and Werner 2000; Qiu and Zhu 2016; Rani and Jayaraman 2010; Sanson and Provenzale 2009; Serra-Pompei et al. 2020; Steele and Henderson 1992; Turner et al. 2014)

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