A method for underwater sampling accounting for dilution

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Abstract

Underwater measurements are important in field biology. Measurements are made from sites of interest that usually have a higher density of specific variables. This requires control over density, because of dilution rates

Introduction

Hypothesis and background

Knowledge gap

How to fill the knowledge gap

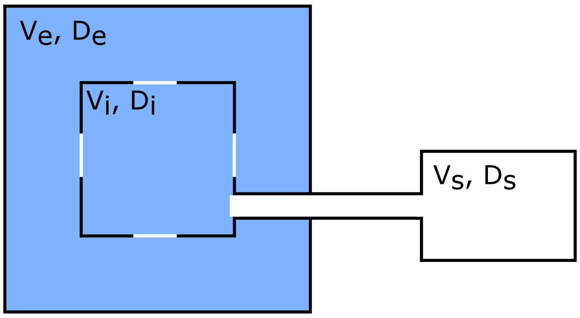

Figure 1: **The subaquatic sampling system consists of an environment (E), a system of interest (I), and a sample (S)** The system of interest (I) is a subset of the environment (E). The hypothesis is that the concentration of certain biogeochemical properties is larger in I than E ($D_I > D_E$). As I is sampled, D_I will decrease by water dilution

Methods

Input	Volume	Density
Environment	$V_E = \inf$	$D_E = 10^6 VLP/ml$
System of Interest	$V_I = 1.4L$	$D_I = 10^7 VLP/ml$
Sample	$V_S = 0.5L$	$D_S =?$
Sample rate	$v = 10ml/s$	

Let I be a subaquatic system of interest in an environment E with a constant volume V_I (Figure 1). Suppose that our hypothesis is that the concentration of a certain biogeochemical property is higher in I than in D, $D_I(t = 0) > D_E$. To test this hypothesis, we take a sample S from I. Let that sample have a volume V_S. As water flows out from I at a rate v, water flows in from E at the same rate, thus diluting the concentration D_I over time.

Given the sample S, with volume V_S, and concentration D_S, we want to be able to infer the initial concentration of interest D_I.

First, we want to get the concentration D_I as a function of time as we extract water at a rate of v. Because V_I is constant, only the mass M_I changes over time:

$$\frac{dM_I}{dt} = (-D_I(t) + D_E)v \tag{1}$$

Integrating, and dividing by V_I we get the density:

$$D_I(t) = D_0 - \frac{1}{V_I} \exp^{-\frac{v}{V_I}t}. \tag{2}$$

This equation can be solved analytically, giving:

The rate of mass M_S is similarly modeled:

$$\frac{dM_S}{dt} = D_I v \tag{3}$$

These equations can be solved analytically giving the following functions:

$$M_I(t) = D_0 V_I - \exp^{-\frac{v}{V_I}t}. \tag{4}$$

$$M_S(t) = vD_E t - (M_I(0) - D_E V_I) \exp^{-\frac{-v}{V_I}t}. \tag{5}$$

Results

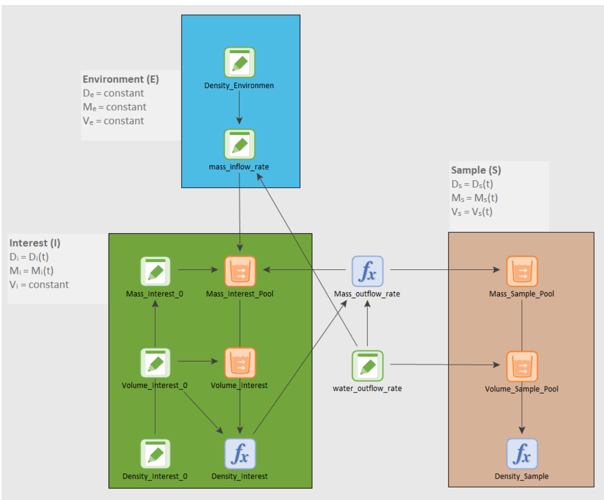

Figure 2: **GoldSim model of the sampling** The model integrates the mass, volume, and density of I and S over time

Discussion

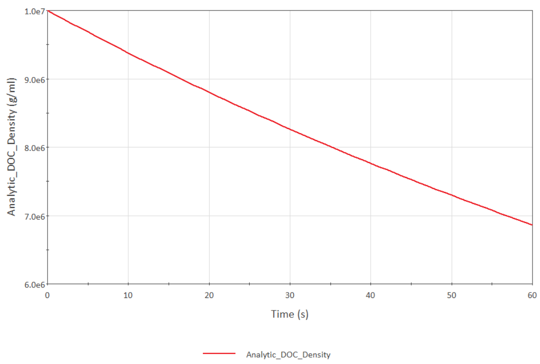

Figure 3: **Density of system of Interest (D_I) over time** D_I decreases exponentially to D_E, the density of the environment

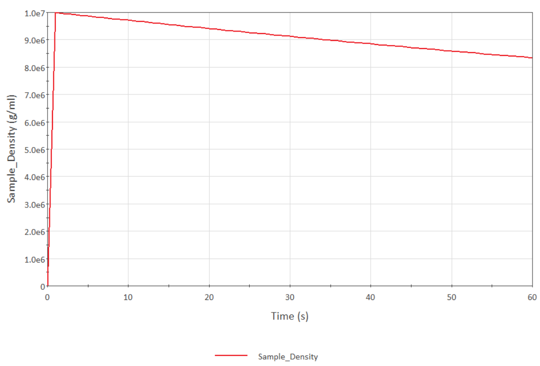

Figure 4: **Density of Sample (D_S) over time**