1 Introduction

An accurate representation of the underwater light field is essential in estimating production rates in aquatic biological models. While it may suffice to use a simple model for downward attenuation in certain circumstances, such as modeling the growth of phytoplankton, some situations which are characterized by significant spatial variance and angular asymmetries such as macroalgae populations may require a more sophisticated optical model in order to account for self-shading, especially considering the dynamic spatial configuration of the kelp in an environment with significantly time-varying water velocity.

On the other hand, ocean-scale hydrodynamical models such as SINMOD generally require computations over large spatial domains, which significantly limit the share of computational resources which can be devoted to any particular aspect of the model. Light models in particular can be very computationally intensive due to the large number of dimensions involved ignoring symmetries (three spatial, two angular). Verily, no benefit will be derived from a realistic model which computational scientists reject for it's computational intensity.

Our objective, then, is to devise a computational technique which accurately depicts the underwater radiation field, while providing a significant improvement over the model of additive vertical exponential decay, which is prevelant throughout biological models. The approches considered here are sourced from the theory of radiative transfer, a macroscopic first-principles formalism. While this approach is widely used in stellar astrophysics, its use in oceanography is scarce and has been largely pioneered by Curtis Mobley in the past half-century.

In particular, we consider the techniques of discrete ordinates, which provides high accuracy at high computational cost; analytical solutions from horizontal homogenization, which is the usual over-simplification used in biology; and the asymptotic techniques of dividing computation into distinct scattering events, which provides excellent approximations with reasonable expense, and whose economy can be variable increased depending on the acceptible error in the solution.