# REMOTE SENSING OF PRODUCTIVITY AND CALCIFICATION OF THE FLORIDA KEYS REEF TRACT

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## 1. INTRODUCTION

Knowledge of coral reef GPP is the foundation for understanding the function of reef systems. GPP sets the maximum energy available to a reef community through autotrophic pathways and ultimately limit the biomass and secondary production of reef consumers [1-3]. Calcification, or the production of carbonate, is directly related to the value of GPP [4]. GPP describes the basic energy production of the system and is therefore important for assessing the overall vitality of the ecosystem: areas rich in algae, seagrass or coral have significantly (~10·) higher GPP than areas covered with sand or rubble [5]. Similarly, the spatial arrangement of GPP describes the fundamental zonation of a reef, which can be interpreted as a measure reef health: healthy reefs exhibit high GPP on fore-reefs, reef-crests and reef-flats, with active sand burial in backreef areas leading to low GPP [4, 6, 7]. Thus, GPP can be affected greatly by changes in reef community structure, such as phase shifts where the benthic community changes from coral-rich to coral-poor. Typically, reef grazers and their predators move—and spatially integrate resources—at the hectare (10,000 m2) scale. Thus, a generally applicable method to measure GPP at the hectare scale, and across reefs/islands/archipelagos, would be very useful to evaluate the trophodynamic consequences of changes in community composition.

Following an approach that is well-developed in terrestrial remote sensing, and somewhat less well-developed in oceanic remote sensing, we [8] have proposed an optical absorptance-based method for determining reef community-scale GPP. The optical-based model for gross primary production (GPP) is

$$\mathrm{GPP} = \varepsilon \int_{\lambda=400}^{700} E_{\mathrm{d}}(\lambda; h) A(\lambda) \qquad (1)$$

where spectral downwelling plane irradiance [$E_d(\lambda;h)$] represents the light flux (quanta) incident to the benthos at a given wavelength ($\lambda$) and seafloor depth ($h$), spectral absorptance [$A(\lambda)$] describes the fractional amount of light absorbed by the benthos (non-dimensional), and community photosynthetic efficiency ($\varepsilon$) is light-use efficiency, the capacity for the community to convert light energy to fixed carbon (C fixed or $O_2$ evolved per quanta). This is the general form of primary production models that are based on light-use efficiency. This type of model was first suggested by Monteith (1972)[9] for tropical and sub-tropical crop plants. It is now routinely used in terrestrial remote sensing studies (e.g., [10-12]) and forms the basis for standard MODIS global land GPP and NPP (net primary production) products [13]. Similar expressions have also been with respect to marine systems [14, 15], including corals [16].

In this study, we determine benthic gross primary productivity (GPP) over the period 1997–2007 for coral reefs in the Florida Keys. We use Landsat imagery (TM and/or ETM+) to determine spatially explicit absorptance of the benthic community, and we use ocean color products (PAR and K490 from SeaWiFS) to drive the light component of the daily GPP model.

## 2. METHODS

The objective is to apply Eq. (1) to remote sensing imagery of coral reefs, thus providing estimates of GPP for reef areas that are too large or inaccessible for in situ biogeochemical studies. $E_d(\lambda;h)$ can be extracted from ocean color remote sensing products, or measured directly. $A(\lambda)$can be derived directly by inversion of remote sensing data. Given appropriate value(s) for $\varepsilon$, determination of GPP requires the simple algebra of Eq. (1). The general algorithm to derive GPP is listed below:

Step 1. Determine $E_d(\lambda;h)$, the spectral downwelling plane irradiance incident to seafloor at depth $h$, for each pixel in image;

Step 2. Invert remote sensing imagery to determine seafloor spectral absorptance $A(\lambda)$ at each pixel in image;

Step 3. Multiply $E_d(\lambda;h)$ by $A(\lambda)$ to determine quanta absorbed by each pixel at each wavelength;

Step 4. Integrate result from Step 3 across wavelengths to obtain total quanta absorbed (i.e., APAR); and

Step 5. Multiply result of Step 4 by appropriate $\varepsilon$ to estimate GPP for each pixel.

## 3. RESULTS

Results show that primary productivity and calcification have remained stable for coral reefs of the Florida Keys over the period 1997–2007. This is in contrast to the documented decline in scleractinian coral cover during the same period. This demonstrates the possibility that reef ecosystems may be resilient to the loss of corals.

## 4. REFERNCES


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