Supplementary Material

Table S1. Details for the various programs that collected *in situ* data.

Region	Program	Description	Source
BATS	BATS	Bermuda-Atlantic Time-series Study	http://bats.bios.edu/
NABE	NABE	North Atantic Bloom Experiment	http://usjgofs.whoi.edu/jg/dir/jgofs/nabe/
NEA	OMEX I, II	Ocean Margin Exchange	T. Smyth
Black Sea	NATO SfP ODBMS	NATO Black Sea Ecosystem Processes and Forecasting / Operational Database Management System	Z. Finenko, National Academy of Sciences of Ukraine, Sevastopol
Mediterranean Sea	DYFAMED	Atmospheric Dynamics and Fluxes in the Mediterranean Sea	http://www.obs-vlfr.fr/cd_rom_dmtt/dyf_main.htm
Mediterranean Sea	FRONTS	Barcelona-Majorca transect	M. Estrada and X. Moran, Institute of Marine Sciences, CSIC, Barcelona, Spain
Mediterranean Sea	HIVERN	Transects across the Catalan front	M. Estrada and X. Moran, Institute of Marine Sciences, CSIC, Barcelona, Spain
Mediterranean Sea	PROSOPE	Productivity of Oceanic Pelagic Systems	http://www.obs-vlfr.fr/cd_rom_dmtt/pr_main.htm
Mediterranean Sea	VARIMED	Transects across the Catalan front	M. Estrada and X. Moran, Institute of Marine Sciences, CSIC, Barcelona, Spain
Mediterranean Sea	ZSN-GN	Zoological Station of Naples - Gulf of Naples	M. Scardi
Arabian Sea	ASPS	Arabian Sea Process Study	http://www1.whoi.edu/research/arabian.html
HOT	HOT	Hawaii Ocean Time-series	http://hahana.soest.hawaii.edu/hot/hot_jgofs.html
Ross Sea	AESOPS	Antarctic Environment and Southern Ocean Process Study	W. Smith
Ross Sea	CORSACS	Controls on Ross Sea Algal Community Structure	W. Smith
WAP	WAP (LTER-PAL)	Palmer Station Long-Term Ecological Research	http://pal.lternet.edu/data/
APFZ	AESOPS	Antarctic Environment and Southern Ocean Process Study	http://www1.whoi.edu/southernobjects.html

Appendix A: Detailed model descriptions

1. DI,WI model descriptions

Model 1: This model estimates NPP as:

$$\mathrm{NPP}\ [\mathrm{mg\ C\ m^{-2}\ d^{-1}}] = [(\mathrm{chl_0}\ [\mathrm{mg\ chl\ m^{-3}}])^{1/2}] \times 1000$$

(Eppley, 1985). It ignores any external forcing or changes in physiological state. While other models incorporate information regarding geography or forcing fields, this model assumes that the standing stock is sole determinant of photosynthetic rate. All biomass performs identically. This simplicity is inherently elegant because biomass is, for most of the ocean, an excellent indicator of nutrient supply and presence of light.

Model 2: This is the original Howard, Yoder, Ryan model (Howard and Yoder, 1997), which for many years was a standard MODIS algorithm. Maximum growth rate is parameterized as a function of SST according to Eppley (1972). NPP is integrated to the MLD rather than to the euphotic depth.

Model 3: This is a variant of the original Howard, Yoder, Ryan model (Howard and Yoder, 1997) which integrates photosynthesis to the euphotic depth as defined in Behrenfeld and Falkowski (1997) rather than to the MLD (Carr, 2002).

Model 4: This model is based on the formulation obtained through dimensional analysis by Platt and Sathyendranath (1993). The photosynthetic parameter (P^B_{max}) is assigned by combining a temperature-dependent relationship for the maximum growth rate (Eppley, 1972) with a variable carbon to chlorophyll ratio following the statistical relationship of Cloern et al. (1995).

Model 5: This model uses an artificial neural network to perform a generalized nonlinear regression of NPP on several predictive variables, including latitude, longitude, day length, MLD, SST, $P^B{}_{opt}$ (computed according to Behrenfeld and Falkowski (1997), PAR, and Chl-*a* (Scardi, 2000; Scardi, 2001).

Model 6: This Vertically Generalized Production Model (VGPM) (Behrenfeld and Falkowski 1997) variant uses the continuous function of Morel and Berthon (1989) to estimate total integrated Chl-*a*, which in turn is used to estimate the euphotic depth with the equations proposed by Morel and Maritorena (2001).

Model 7: This VGPM variant formulates $P^B{}_{opt}$ as a function of SST and Chl-*a* (Kameda and Ishizaka, 2005; Yamada et al., 2005). The model is based on the assumption that phytoplankton consists of large and small phytoplankton groups, which have specific Chl-*a* productivities and temperature functions such that changes in Chl-*a* concentration depends on the abundance of large phytoplankton.

Model 8: The original VGPM developed by Behrenfeld and Falkowski (1997) is one of the most widely known and used NPP models. The maximum observed photosynthetic rate within the water column, $P^B{}_{opt}$, is obtained as a 7th-order polynomial of SST.

Model 9: This model only differs from Model 8 in that $P^B{}_{opt}$ is estimated as an exponential function of temperature following Eppley (1972).

Model 10: This model (Tang et al., 2008) uses support vector machine (SVM) as the nonlinear transfer function between ocean primary productivity and Chl-a concentration, euphotic layer depth, PAR, maximum carbon fixation rate and day length. The maximum carbon fixation was estimated by using a seventh-order polynomial function of SST

(Behrenfeld and Falkowski, 1997). The euphotic layer depth was estimated using the integrated chlorophyll (Morel and Berthon, 1989).

Model 11: This model is similar to Model 13 (Tang et al., 2008) except that the maximum carbon fixation rate was estimated as a SVM-based nonlinear function of SST, Chl-*a* and PAR.

2. DR,WI model descriptions

Model 12: In this model the depth-distribution of PAR is given by an empirical equation of light attenuation, which is determined by chl_0. The depth-distribution of Chl-*a* is determined by an empirical equation of PAR and Chl-*a* along the PAR depth-distribution line in a log scale with estimating a chlorophyll maximum up to 0.1 % depth of PAR. Total productivity is empirically estimated and integrated from surface to 1 % euphotic zone and for a day light time as a function of SST, depth-dependent PAR, Chl-*a*, latitude, and seasons (Asanuma, 2006).

Model 13: Photosynthesis per unit Chl-*a* was determined using an optimality-based model of nitrogen allocation and photoacclimation (Armstrong, 2006); the optimality criterion was derived based on the photosynthesis model of Geider et al. (1998). Photoacclimation and nitrogen allocation were determined as a function of light and temperature; therefore both PAR and SST were used in the productivity algorithm. Maximum photosynthetic rates were based on NPP estimated for *T. weissflogii* in Armstrong [2006], and were assumed to have Eppley (1972) temperature dependence; photoacclimation parameters were also as in Armstrong (2006). Through the photoadaptation algorithm, Chl-*a* reflects nitrogen status, so that no assumptions about nutrient limitation are needed. Chl-*a* concentration was assumed constant over the photic zone and equal to surface Chl-*a*, so that light decreases exponentially with depth. Photic zone depth (1% light) was determined from Chl-*a* concentration and assumed extinction coefficients. The photic zone was assumed to be well mixed and cells were assumed to be photoacclimated to the light level at the middle of the photic zone (10% of surface illumination light. Column productivity is the integral over the photic zone of (photosynthesis/Chl-*a*) x Chl-*a*.

Model 14: This is a variant of Model 13 where the photic zone was divided into two equal depth (photoacclimation) zones (10%-100% and 1%-10% surface illumination, respectively), and separate photoacclimation parameters were calculated for the upper and lower parts of the photic zone (31.6% and 3.16% surface illumination, respectively).

Model 15**:** The Ocean Productivity from Absorption and Light (OPAL) model generates profiles of chlorophyll estimated from surface chlorophyll based on Wozniak et al. (2003) and uses the absorption properties in the water column to vertically resolve estimates of light attenuation in approximately 100 strata within the euphotic zone. Absorption by pure water is assumed to be a constant value over PAR wavelengths; chlorophyll-specific phytoplankton absorption is parameterized empirically (Bricaud et al., 1998); absorption by photosynthetic pigments is distinguished from total absorption; and absorption by colored dissolved organic matter (CDOM) is calculated according to Kahru and Mitchell (2001). The chlorophyll-specific phytoplankton absorption is used to calculate productivity, while absorption by photosynthetic pigments, water, and CDOM are used to vertically resolve light attenuation. SST, which is used as a proxy for seasonal changes in the phytoplankton community, is related to the chlorophyll-specific absorption coefficient. The quantum efficiency is obtained from a hyperbolic tangent and a constant φmax. Productivity is calculated for the 100 layers in the euphotic zone and summed to compute the integral daily productivity.

3. DR,WR model descriptions

Model 16: This is a spectral light-photosynthesis model published by Morel (1991). It is formulated using Chl-*a* specific wavelength-resolved absorption and quantum yield. Temperature dependence is given by the parameterization of P^B_{max}, which follows *Eppley* (1972). The CHL profile is determined to be well-mixed or stratified according to the ratio of MLD and the euphotic depth, and if stratified, assigned a gaussian profile as in Morel and Berthon (1989). Mean photo-physiological parameters are from Morel et al. (1996). The model is run in its `satellite' version Antoine et al. (1996), where NPP is the product of integral biomass, the daily irradiance, and ψ^*(the cross-section of algae for photosynthesis per unit of areal Chl-*a* biomass). Lookup tables for ψ^* were previously generated using the full DR,WR model, and are used to increase computational efficiency.

Model 17: This is a variant of Model 16 that considers separately the micro-, nano-, and pico-phytoplankton size classes to determine NPP (specific parameterizations for the Chl-*a* vertical profile (Uitz et al., 2006) and for the photo-physiological parameters (Uitz et al., 2008).

Model 18: This model follows that of Platt and Sathyendranath (1988) as implemented at global scale by Longhurst et al. (1995). It uses biogeographical provinces to define the values of the parameters to describe the light-photosynthesis curve and the Chl-a depth profile. Photosynthetic parameters were updated using an extended data set provided by the Bedford Institute of Oceanography and an extensive literature review. Spectral surface irradiance is first estimated independently with the model of Gregg and Carder (1990) combined with a correction for cloud cover and then scaled to match the PAR values provided for the exercise. Spectral light is subsequently propagated in the water column with a bio-optical model with updated parameterizations of the inherent optical properties. All changes to the original implementation of Longhurst et al. (1995) are detailed by Mélin (2003).

Model 19: This model is an implementation of the Morel (1991) model in which the depth distribution of Chl-*a* is assumed constant throughout the water column. The broadband incident PAR is spectrally resolved using a look-up-table generated from a single run of the Gregg and Carder (1990) marine irradiance model where the effects of clouds and aerosols are essentially linearly scaled. The model uses 60-minute time and 10-m depth steps at 5-nm wavelength resolution when run using the global datasets (Smyth et al., 2005).

Model 20: This model derives spectral irradiance from PAR using Tanré et al. (1990), and assumes a vertically uniform Chl-a profile. Quantum yield is parameterized as a maximum value times both a light dependent term (Bidigare et al., 1992; Waters et al., 1994) and a temperature dependent term. Temperature dependence was assumed to be sigmoidal, and was based on a vertical profile of temperature derived from SST and MLD.

Model 21: This model is identical to Model 20 except the temperature dependent term is removed.

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