Light irradiance at the sea surface and sea floor

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Sea surface and seafloor irradiance

Overview: Sea surface and seafloor irradiance were recorded once or twice per minute at shallow subtidal reefs off Santa Barbara, California beginning in 2008. Sites were chosen to represent a range of physical and biological characteristics known to influence the structure and productivity of subtidal reef communities in the region. A ubiquitous (but not always persistent) feature on these reefs was the presence of giant kelp, which forms a dense canopy at the sea surface that alters the biomass, diversity and temporal stability of reef biota (Castorani et al. 2018, Miller et al. 2018, Lamy et al. 2020).

Irradiance was measured using submersible spherical PAR sensors (MKV-L, Alec Electronics, Japan) from 2008-2015 and submersible planar PAR sensors (DEFI-L, Alec Electronics, Japan) from 2016 to the present. Measurements were averaged over the course of each hour and data are presented as average instantaneous irradiance per hour in units of µmol m^{-2} sec^{-1}.

Measurements of seafloor irradiance: PAR sensors were mounted ~ 30 cm off the bottom on rebar stakes using stainless steel hose clamps. Sensors were retrieved for data download and servicing every 6-12 weeks and simultaneously replaced with newly serviced sensors. Sensors were wrapped in black electrical tape during transport from the laboratory to the field to ensure that all light readings prior to deployment were zero. Once deployed underwater the tape was removed and the time of deployment noted in an event log.

Biological fouling (primarily by benthic diatoms) on the sensors occurs to varying degrees during deployment which affects measurement accuracy. To account for attenuation of light due to biofouling we cleaned the sensors in situ 20 minutes before retrieval and calculated attenuation (*a*) by biofouling as

$$(a) = -\ln\left(\frac{dirty}{clean}\right)$$

where *dirty* represents the mean irradiance sampled once per minute for 20 minutes prior to the sensor being cleaned on retrieval day, and *clean* represents the mean irradiance sampled once per minute for 20 minutes immediately after cleaning. The effects of biofouling on irradiance were assessed by comparing mean dirty and mean clean irradiance using a student's t-test with $\alpha = 0.05$. Irradiance values from significantly fouled sensors were corrected on each day of the deployment using the equation:

$$Corrected\ irradiance = Measured\ irradiance * \exp\left(\frac{a}{\sum d}\right) * t$$

Here, *a* represents attenuation due to fouling as described above, *d* represent the total number of days since deployment (over which we assume the fouling accumulated), and *t* represents the number of days that have passed since deployment for the set of values being corrected (Harrer et al. 2013).

Discontinuation of the MKV-L spherical sensors led us to switch to the DEFI-L planar sensors, which record lower values of seafloor irradiance (particularly at low light levels) because they measure light over a narrower optical field. We used data (see data package https://portal-s.edirepository.org/nis/mapbrowse?scope=knb-lter-sbc&identifier=128) collected during simultaneous deployments of paired MKV-L and DEFI –L sensors to develop algorithms to convert all values recorded from planar sensors to values representative of spherical sensors by curve fitting for the parameters *A*, *t*1 and *y* in the equation of Long et al. 2012:

$$Spherical\ sensor\ value = A * e^{-planar\ sensor\ value/t1} + y$$

Conversions from planar to spherical values were applied to all data collected between 06:00 and 20:00 local time using the equation:

$$Spherical\ sensor\ value = 20000018 * e^{-planar\ sensor\frac{value}{11064484}} - 20000000$$

Measurements of sea surface irradiance: From 2008-2015, irradiance was measured from MKV-Land DEFI-L sensors mounted ~30 to 100 cm above the sea surface on a moored vertical spar buoy at three reefs (Arroyo Quemado, Carpinteria and Mohawk). The sensors were calibrated for readings in air by the manufacturer. The time series obtained from these sensors proved difficult to maintain due to sensor damage and loss caused by storms and boat traffic. Because of this and the fact that sea surface irradiance was highly similar among reefs (unpublished data) a single surface sensor was deployed on an unobstructed rooftop at the University of California Santa Barbara beginning in 2016. Sea surface values were not adjusted for biofouling because it did not occur. Similarly, there was no need to convert values of sea surface irradiance obtained from planar sensor to values representative of spherical sensors because irradiance values recorded by the two types of sensors at the sea surface were nearly identical.

References

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