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# Editorial: Optics and ecophysiology of coral reef organisms: volume II

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## Editorial on the Research Topic

### Optics and ecophysiology of coral reef organisms: volume II

Light is the fundamental energy fuelling life on coral reefs (Dubinsky and Falkowski, 2010). Photosynthetic microalgal symbionts (Symbiodiniaceae) hosted inside coral cells provide most of the carbon required to support the growth and reproduction of calcifying coral colonies, which in turn create the complex physical reef infrastructure that lays the foundation for this entire ecosystem (Muscatine, 1990). To thrive in nutrient-poor tropical waters, the coral holobiont must balance variable light regimes. Excessive irradiance can result in photoinhibition, oxidative stress, and the potential breakdown of the coral-algal symbiosis (i.e., coral bleaching), while insufficient light limits coral growth rates. Corals and their symbionts have evolved a variety of mechanisms to cope with extreme light regimes and such optimization takes place on a wide range of biological scales, from photon capture and photochemistry in the photosynthetic apparatus of symbiont chloroplasts, all the way to colony-level morphological plasticity (Dubinsky and Falkowski, 2010).

Light is also an invaluable source of information for scientists researching coral reefs. Optical methods are non- or minimally-invasive, enabling repeated monitoring of the same samples with high frequency to capture dynamic processes over short and long-time scales. Additionally, although they may require an initial investment in specialized or custom setups, the requirement for consumables is generally low. Optical methods are thus highly scalable, and particularly suited for the development of high throughput applications. Scalability has been a central topic in coral reef science over recent years. New discoveries of promising approaches that could enhance coral resilience to climate change are being reported every day – from administration of probiotics to identification and selective breeding of stress tolerant genets (Voolstra et al., 2021). But the challenge remains of how to scale these approaches to make application feasible in the context of restoration, and attractive to industry and policy. By providing high throughput, high frequency, long term

and low-cost monitoring of various health parameters, optical methods promise to help bridge the gap between research and application. Particularly, we anticipate that optical methods will become the state of the art for large scale, rapid measurement of coral physiological response in assays aimed at determining the fitness of selectively bred coral genets, and the efficacy of other treatments aimed at increasing stress resilience.

As part of the global endeavour to increase our understanding of coral reefs and predict how they will respond to environmental change, considerable research effort has been directed towards modelling approaches. Our ability to model processes that occur inside individual polyps, colonies or over entire reefs has dramatically increased over the past few years, to the point that these models can now be linked and integrated. These modelling approaches thus promise holistic predictions that span multiple levels of biological organisation, and allow us to answer questions across broad spatial and temporal scales. The articles showcased in this Research Topic highlight how a variety of optical and ecophysiological methods can be used to tackle important questions in coral biology at all levels of organismal organization and over a range of spatial and temporal scales.

Aslam et al. provide an example of how chlorophyll fluorescence can be used to non-invasively study photosynthesis in Symbiodiniaceae. Variable chlorophyll fluorescence is one of the most widely applied optical methods to assess photophysiological health in coral holobionts (Warner et al., 2010), and is often included in systematic screening of stress tolerance (e.g., Voolstra et al., 2020). While most applications on corals have focused primarily on estimating coral health via measurements of the maximum quantum yield of photosystem II (PSII) activity, variable chlorophyll fluorescence measurements can yield much more detailed insights into photophysiology, including information about alternative electron transport pathways such as cyclic electron flow (Asada et al., 1993). These pathways can underpin differences in how symbiont species and genotypes respond to environmental stress, and are thus of interest for the purpose of screening the fitness of different coral-Symbiodiniaceae associations. The authors investigated the chlorophyll fluorescence kinetics in Symbiodiniaceae via measuring flash-induced fluorescence relaxation under microaerobic conditions and/or during partial inactivation of PSII. The method enables monitoring of various components of the photosynthetic electron transport chain and was here used for the first time in Symbiodiniaceae. Measurements showed a pronounced species-dependent effect on fluorescence kinetics by the combination of heat stress and microaerobic conditions. These results highlight a potential avenue for further exploration of photophysiological differences between symbiont taxa and their role in holobiont health during the climate crisis.

An example of how variable chlorophyll fluorescence can be scaled up to assay holobiont fitness with high throughput is presented by Hoadley et al. Their method employs a custom-built multispectral fluorometer to excite different photosynthetic pigments *in hospite* and collect measurements of various photosynthetic parameters, resulting in a total of 40 individual metrics generated for each sample. Screening of multiple genotypes of two Caribbean coral species during a heat stress experiment

enabled the authors to correlate bleaching metrics with photophysiological responses and identify biomarkers of thermal stress. While some individual metrics, such as non-photochemical quenching, were particularly highly correlated with bleaching susceptibility, the results show how the use of multiple markers for each individual sample can provide much more accurate bleaching predictions compared to a single marker.

Further highlighting the potential of novel optical methods in coral research, Jaffe et al. present a method to estimate key structural parameters of coral biology (polyp volume and surface area) with high accuracy and resolution via analysis of optical coherence tomography (OCT) scans of living corals. OCT enables non-invasive mapping of the external and internal tissue structure of living corals (Wangpraseurt et al., 2017). Corals can exhibit pronounced tissue plasticity and analysis of OCT data shows that such tissue movement can easily change surface area to volume ratios by a factor of 2 or more. Accurate measurements of these values can be fed into models that cover all scales from single polyp to whole colony and eventually reef scale, helping to integrate these aspects into a more holistic view.

An example of how models of coral ecophysiology can underpin a broader understanding of reef-scale processes is provided by Dişa et al. Their study links coral physiology with biogeochemical cycles and ocean circulation to create a coupled model that can resolve these variables over space and time. Their model highlights large variations in ocean biogeochemistry driven by coral metabolic processes during the day-night cycle, as well as spatial biogeochemical niches which might expose corals to different levels of environmental stress, thus potentially contributing to differential adaptation and acclimatization to future ocean conditions.

Optical methods can also be used to investigate the ecophysiology and bio-optics of the coral host. Initial studies on the role and regulation of host pigments of the Green Fluorescent Protein (GFP)-like family have been regarded as promising in the search for non-invasive biomarkers of holobiont physiology, since they are responsive to environmental conditions and are easily detectable due to their distinct absorption and emission properties. However, application of these proteins as biomarkers has been hindered by the great diversity in terms of spectral properties, regulation mechanisms, and function displayed by this pigment group across Scleractinia. Ferreira et al. review this diversity, and bring forward a road map of best practices and knowledge gaps that need to be addressed in order to push the field forward.

The articles presented in this Research Topic build on our previous collection (Wangpraseurt et al., 2019) to highlight recent advances in the field of coral ecophysiology and optical methods. We hope this will facilitate future developments in these fields, as well as their application to solving the challenges presented to coral reefs by the climate crisis.

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## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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