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The University which the work is carried out: Tel-Aviv University

Title: The effect of light on the distribution and community structure of stony corals along a 5-100 m depth gradient

In the current study, I sought to address the gap in our knowledge regarding the effect of the light field, along with the environmental variables (e.g. chlorophyll and sediment) that affect its quality, on stony corals' bathymetric distribution. My in-depth light and ecological surveys carried at five sites in the Red Sea, to 100 m depth, covering the mesophotic zone, present the first study built upon the recognition of shallow and mesophotic reefs as a single biological entity (1). Two distinct assemblages of stony corals, shallow and mesophotic, were detected as possessing markedly different relationships with light (Fig. 1.). This study's findings also describe the relationship between light quality and depth 'generalist' and 'specialist' coral species along the reef slope or at specific depths, with the depth range of 29 coral genera in the Gulf of Eilat/Aqaba being better explained by light than by depth. I also describe coral distribution based on the skeletal morphological structure; with branching species-dominating shallow depths (<40 m), foliaceous species dominating 40-80 m depth, and a massive light-dependent coral threshold at 70 m depth. I have identified an ecological phenomenon - while finding that seasonal algal blooms plays a significant role in structuring the coral communities of the studied reefs. This phenomenon is suggested to structure the observed coral communities by modulating the long-term light environment, while the peak of chlorophyll-*a* concentration, following the seasonal algal blooms, coincide with the months of light data that best explain assemblage distributions.

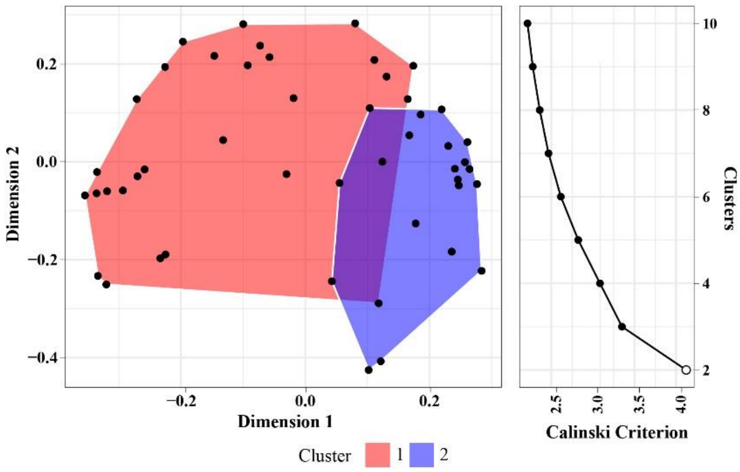

Fig. 1. Principal coordinate analysis of quadrat data was used to identify assemblages of co-occurring Scleractinia genera with K-means clustering (left). Polygons show the degree of overlap between clusters in taxon space. The Calinski criterion of proposed number of clusters to fit to the data is shown to the right. The optimal number of clusters was considered to be the number that maximized the Calinski criterion, marked as a hollow point.

However, coral reefs worldwide exhibit variability in the pattern of distinct communities with increasing depth. Hence, it was important to determine to what extent the coral community pattern described above for the GoE/A typifies coral reefs world-wide, and to link together these findings within a quantitative framework. In order to clarify these potential patterns, I present a theoretical, process-based model of the influence of light on the shallow-to-mesophotic reef transition as a single quantitative framework (2). I also make available interactive web application, thereby presenting for the first time a generalized, mechanistic, light-driven model of the shallow-to-mesophotic reef transition (Fig. 2.). Based on a suite of equations, this process-based model provides a focal tool that can be used to explain field-based definitions of transition zones and the structure of ecological communities. Additionally, this tool can be used to identify and answer vital research questions for the future benefit of the coral reefs.

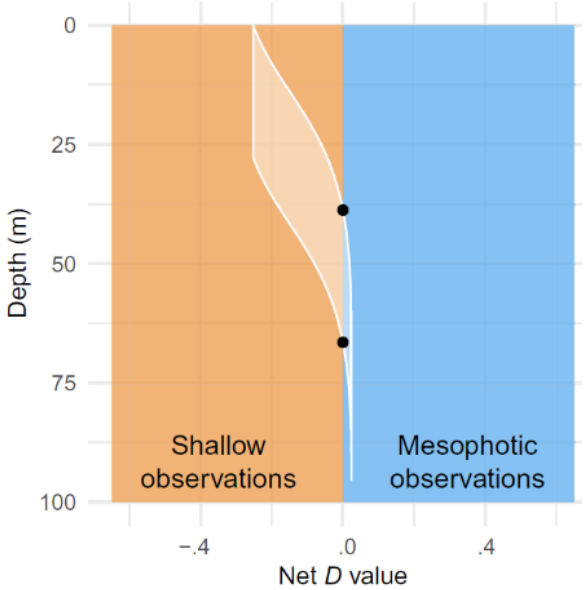

Fig. 2. Predicted community identity along a theoretical depth gradient on a coral reef. The model output is shown as a pale ribbon. The range covers the predicted depths for particular community values following the shaded and non-shaded light–depth relationships. Positive net D values (blue) indicate a mesophotic community. Negative values (orange) indicate shallow communities. Black points show the depth boundaries of the upper mesophotic zone (D = 0). The value for this plot is parameterized for the Red Sea according to Tamir et al. (2019)

In addition to the crucial physio/ecological data provided here, a long-term (one year) reciprocal transplantation experiment conducted in order to assess the potential responses and acclimatization ability of corals species (*P. lobate*, *P. peres*, *M. danae*, *A. squarrosa*, and *S. pistillata*) to different light, sediment, and nutrient conditions (3). My study of the survivorship and changes in the photobiological acclimatization of these species following their cross-transplantation between two different depths (5-10 m and 45 m), and two sites characterized by different abiotic conditions (i.e. light, nutrient, and sedimentation regime), provides crucial data on the variable ability of five depth-generalist coral species to contend with different environmental conditions. Depth of origin and the species' particular morphology (e.g. massive, branching, and laminar) were found to be the strongest predictors of survivorship, with the massive morphologies (*P. lobata* and *P. peresi*) exhibiting an overall greater survivorship percentage than the laminar (*M. danae*) and branching species (*A. squarosa* and *S. pistillata*). Additionally, the massive species exhibited photoacclimation following transplantation. This was expressed in physiological responses (e.g. reduction in chlorophyll-*a* concentration and algal density), as well as changes in the photosynthetic parameters (e.g. maximal saturating points, E_k, and $rETR_{max}$). These findings contribute to the existing knowledge on the ability of species-specific coral responses to contend with dramatic changes in light with depth. Furthermore, they indicate that the ability to contend with the predicted long-term environmental changes that result from extreme environmental events, is also species-specific.

Although sunlight plays a crucial role in coral distribution, lighting conditions at night may also have a considerable effect on their settlement, survivorship, and growth at particular sites. Knowledge of the potential effect of light pollution on ecological systems such as the marine environment, and coral reefs specifically, is lacking. To date, despite an increase in the number of studies carried out in the context of this important issue, the artificial near-shore lighting effects on coral early life stages (e.g. settlement and growth) and crucial physiological parameters (e.g. photosynthesis efficiency and calcification rate) remain unknown. In this work I sought to spread new light on the potential effects of this modern phenomenon and its implications for corals (4). The findings from this novel long-term experiment quantify the effect of two common city lighting methods (fluorescent and LED) on the most abundant northern Red Sea coral (*Stylophora pistillata*). I now provide evidence of the potential adverse effects of artificial lighting methods on coral settlement success, survivorship, growth rate, photosynthetic efficiency, and calcification. Corals under artificial lighting conditions exhibited ~30% lower settlement success compared to the control (ambien light) (Fig. 3.). In addition, under artificial light treatments (LED and florescent), the studied corals showed higher survivorship, growth, and calcification rates. An indication of damage to the photosynthetic system was nonetheless found in the light-polluted corals, as reflected in their photosynthesis efficiency. This study thus takes a major step towards acquiring a deeper knowledge regarding the potential ecological effects of different artificial lighting methods on the corals' initial life-stages, LED lighting demonstrating the highest interference potential. Finally, this study presents a crucial tool that can be applied to ensure efficient ecosystem management and a scientific understanding with regard to the implications of artificial lighting for coral reefs.

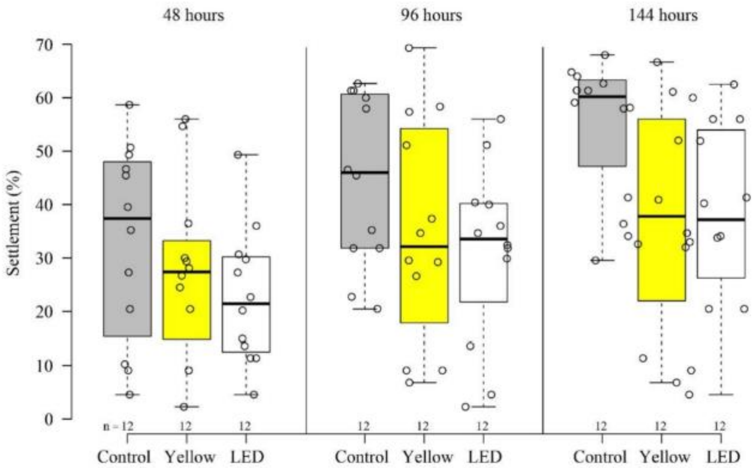

Fig. 3. *S. pistillata* settlement (%) after 48, 96, and 144 h, under ambient conditions—control (gray), 'Yellow' (fluorescent lamp, yellow) light, and 'LED' (LED lamp, white) treatments. Each circle represents settlement (%) on an individual tile. Black center lines represent the medians; box limits represent the 25th to 75th percentiles of the data; whiskers extend to min and max values.

References

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