
ULTRAVIOLET RADIATION AND CORAL REEFS

EDITED BY:

D. GULKO AND P. L. JOKIEL

HAWAII INSTITUTE OF MARINE BIOLOGY

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'Ultraviolet Radiation and Coral Reefs'**

Hawai'i Institute of Marine Biology

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Introduction

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It has been many years since solar ultraviolet radiation was clearly identified as an important ecological factor on coral reefs (Jokiel, 1980), so it seemed timely to organize a major multi-disciplinary project designed to evaluate the state of the art, conduct research, train new researchers in the field and evaluate techniques and methods of measurement in common use today on coral reefs. Major funding for the research and educational function was granted by the Edwin W. Pauley Foundation for an advanced research and training program at the Hawai'i Institute of Marine Biology (HIMB) entitled "Ultraviolet Radiation and Coral Reefs" that was held from June 15 to August 2, 1994. In addition, the University of Hawaii Sea Grant Program funded an international workshop entitled "Measurement of Ultraviolet Radiation in Tropical Nearshore Environments" that was held at the East-West Center (University of Hawai'i, Honolulu, Hawai'i) from August 3-5, 1994. The US-Israel Binational Science Foundation supplied additional funding for participants from Israel and supported the participation by Dr. Dave Mauzerall, our keynote speaker for the workshop.

This volume contains much of the information developed during the 1994 program. Additional research papers are still in preparation by some of the participants and will be forthcoming in various journals. A very important intangible outcome was the sharing of ideas, establishment of research links between various groups and the formulation of new research directions. One example of this was the design of an underwater video system capable of detecting visual patterns in the UV portion of the spectrum. Many fish and invertebrates have the ability to visually detect UV, so they must somehow use UV to obtain information about their environment. This totally new instrument will allow us to "see" as these fish and invertebrates "see" in the UV-range for the first time. The construction of the instrument designed during the 1994 program was recently funded by the US National Science Foundation. Although the instrument will be located at HIMB, it will be used by an international group of scientists including the workshop participants that contributed to its design.

The 1994 program addressed topics from the molecular to the ecosystem level. One can simply examine the following "Table of Contents" to gain appreciation for the wide range of UV topics covered by the participants. By the end of the program, there was a general consensus on the following major points:

- UV is an important environmental factor in shallow tropical ecosystems, influencing living systems at all levels of organization from molecular to community. The importance of UV should not be surprising, given the role of this factor in the origins and evolution of life as described in Dr. Mauzerall's plenary address.
- Although the all-pervasive influence of UV can be shown by experimental treatments of "UV present" vs. "UV absent", it is another matter to conduct experiments that evaluate the possible importance of future increases in UV resulting from anthropogenic ozone thinning. Major obstacles to progress in this area include: 1.) lack of data on spectral irradiance reaching the earth's surface at low latitudes, 2.) lack of a reliable predictive model that can provide data on future increases in spectral irradiance, and 3.) lack of biological data on possible importance of such increases. An immense expenditure of research resources will be required to gain the needed information in these areas due to the technical difficulties encountered in measurement of UV, difficulties in simulating experimental regimes of increased UV and complexities in evaluating effects of a slight UV increase on an ecosystem.

- The chief obstacle to assessment of increased UV on shallow water tropical reef communities lies in their demonstrated complexity, susceptibility and adaptability to UV. Using the terms "susceptibility" and "adaptability" appears to be a paradox. On one hand, reef organisms are living at the highest levels of UV found in the oceans, and show remarkable ability to adapt to extremely high levels of UV. Can these organisms readily adapt to levels of UV that are even higher than presently encountered at the surface of the ocean? This is probable, but has yet to be demonstrated. The UV-blocking compounds in reef corals serve as a good example of a mechanism allowing corals to adapt to a wide range of UV environments at little metabolic cost. On the other hand, UV has been shown to influence most aspects of coral metabolism and impacts all stages in the life cycles of various organisms. In addition, interaction of UV with other physical factors (e.g. temperature-UV synergism's) or processes such as UV-phototoxicity can exacerbate the intensity of other environmental stresses acting on reefs, and in these cases UV produces more damage than anticipated. Every argument as to the sensitivity of reefs to UV damage seemingly can be met with a counter argument that adaptation or acclimation will return the reef to equilibrium.
- Participants in the 1994 program came to the conclusion that UV research must always be "question-driven". This attitude was most apparent in discussions of UV-measurement instrumentation. The group advocated use of appropriate measurement techniques for the question being asked, with due regard to cost effectiveness, rather than selection for standardized instrument. Many biological questions can be resolved using simple and inexpensive actinometric techniques or dosimeters. Some questions are best asked using Robertson-Berger sunburning units or similar units. Other questions, including the monitoring of existing and future trends in solar UV irradiance reaching the surface at low latitudes will require extremely sophisticated scanning spectroradiometric monitoring systems that could be prohibitive, given present research funding levels. Again, the participants argued that first one must ask a legitimate scientific question and then specify the UV measurement technique to be employed.
- It is clear that we have only scratched the surface of basic UV-related research topics. The first demonstration of UV-phototoxicity was conducted during the 1994 program (Peachey and Crosby, this volume). Our embarrassingly small base of information on UV and coral reproduction was expanded by the studies of Gulko (this volume) and Baker (this volume). Scientists concerned with the emerging question of UV, polarization and vision in tropical marine animals point out the lack of information in this important area (Shashar, Shashar et al., this volume, Shashar et al., this volume, Losey et al., this volume). The first broad scale measures of UV attenuation in Kaneohe Bay were made during the program (Patterson, this volume). Numerous other studies in this report demonstrate the fertile research ground available for UV research in tropical marine systems, and a myriad number of research questions were raised by the participants (e.g. Discussion at Workshop Sessions, this volume).
- The group as a whole recognized the need for research centers in tropical reef areas that would be available to all. This recommendation is being implemented. We have secured an NSF grant to purchase the underwater UV video system mentioned earlier for use by the group of international scientists involved in this work. Further, NSF has provided funds to purchase a scanning underwater UV spectroradiometer for HIMB. The data base developed in Kaneohe Bay during the session will be invaluable to researchers using our facility. The University of Hawaii recently purchased all of Coconut Island (which includes housing to be used by visiting investigators) and is building a new \$8.3 million dollar laboratory with a gift from the Edwin W. Pauley Foundation. Therefore, we are well on the way of meeting this recommendation by establishing this facility as a center for UV research.

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Jokiel, P. L. (1980). Solar ultraviolet radiation and coral reef epifauna. *Science* 207:10691071.