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The twilight zone of modern and fossil reefs in the Ryukyu Islands

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Coral reefs are one of the most diverse ecosystems in the World. However, most census data on macrobenthic organisms are limited to shallow reef environments above the depth limit of SCUBA diving. In this study we show taxonomic data from ROV video images of a modern reef ecosystem and from uplifted Pleistocene coral limestones to discuss the nature and distribution of reef corals in the deep photic zone (>30 m water depth) in the Ryukyu Islands. The ROV video images were taken on the fore-reef slope of the Sekisei Lagoon, South Ryukyus, between 40 and 100 m water depth. Three types of macrobenthic communities can be identified. The first is dominated by tabular branching Acropora spp. and occurs between 40 and 55 m water depth. The second is characterized by scleractinian corals with encrusting and laminar morphologies and occurs between 55 and 70 m water depth. The third is dominated by sea fans associated with organisms such as whip-like octocorals and sponges, and is observed between 70 and 100 m water depth. The large benthic foraminifer Cycloclypeus carpenteri occurs below 60 m water depth. Coral cover decreases sharply below 50 m depth. The macrobenthos occurs preferentially on hard substrate and particularly on topographic highs. Fossil deep fore-reef coral assemblages can be identified on the basis of their taxonomic and morphological compositions and their close relationship with deep-water components such as rhodoliths and the large benthic foraminifers Cycloclypeus and Operculina. Typically, coral morphologies are laminar, either encrusting, plate-like or foliaceous, a few mm to cm in thickness. Encrusting and plate-like corals are mainly Porites sp(p.). and Montipora sp(p.). Small encrusting colonies of Stylocoeniella sp. may also be locally common. Foliaceous to encrusting corals include Leptoseris spp., Pachyseris speciosa and Echinophyllia sp. The morphological compositions of modern and fossil deep coral assemblages are similar. However, in-situ colonies of Acropora sp. have not been found in fossil deep coral assemblages, although its occurrence down to 60 m water depth is attested by the video survey. The present study emphasizes the need to expand the exploration of reef environments to the deep photic zone, which remains largely understudied and poorly known. Two useful means to achieve this goal are the utilization of new underwater technologies and the study of uplifted Pleistocene coral limestones.

Keywords: reef corals, deep photic zone, Ryukyu Islands