

## Projected effects of global warming on coral reefs in seas close to Japan

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Global warming is considered to be a crucial factor for future corals, by intensifying chances for coral bleaching or death and inducing coral habitat migration toward higher latitudes caused by the water temperature rise. The world's highest-latitude coral reef exists in the north of the Kyushu Island, Japan (Yamano et al., 2001), and therefore, the effects of global warming are expected to appear most dramatically in the transition zones between the subtropical and temperate oceanic regions.

Using projected water temperature in the 21st century, this study aims to evaluate quantitatively anticipated effects of global warming on corals in seas close to Japan, especially focusing on: (1) coral bleaching and death in the Ryukyu Islands and (2) coral habitat migration in the Kyushu and Honshu Islands. To evaluate state of corals from 2000 to 2099, we use projected monthly-mean water temperature under the A1B scenario in the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) calculated by a high-resolution climate projection model (MIROC3.2(hires) developed by CCSR/NIES/FRCGC).

Degree Heating Month (DHM) is introduced as a simplified evaluation metric for stress of corals on the water temperature, i.e. coral bleaching and death. In this index, coral bleaching is assumed to appear when higher water temperature by more than 1°C than the warmest-month climatology lasts for more than 1 month. Coral death is assumed to occur when higher water temperature by more than 1°C (or more than 2°C) than the warmest-month climatology lasts for more than 2 months (or more than 1 month).

We introduce three simplified indices which express the northern limit of coral and coral-reef distribution. The isothermal lines of 18°C, 13°C, 10°C in the coldest month denote the northern limit of subtropical coral reefs, high-latitude coral reefs, and high-latitude coral habitat, respectively.

Our result shows that the water temperature rise due to global warming affect strongly future coral reefs. Both frequency and area of coral bleaching or death in the Ryukyu Islands is expected to be intensified. Particularly, high water temperature which yields coral death will appear perpetually after 2060s. On the other hand, the northern limit of the coral habitat is expected to migrate northward by 200km, up to Aomori and Iwate Prefectures at the end of the 21st century. Such projections may help re-design local industries such as fisheries and tourism, and location of marine protected areas and parks in future.

This study picks up the effects of the water temperature rise out of various stressing factors on corals by global warming. To provide more realistic projection, however, we also need to consider the other effects of global warming (e.g. sea level rise, stratification, current change, increase of extreme climate) and the other stresses on corals (e.g. low salinity, strong light and ultraviolet light). Because of coral's inherent adaptation and resistance properties, recovery time from bleaching may change in future. These possible effects are to be taken into account by collaborating with long-time integrative monitoring studies.

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