Press Releases

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JAMSTEC

Mechanism of Resilience in Communities with Different Size Distributions
-Underlying mechanism of biodiversity-productivity relationships Clarified -

Overview

A research team led by Dr. Sherwood Lan Smith at the Research and Development Center for Global Change, Japan Agency for Marine-Earth Science and Technology (JAMSTEC: Asahiko Taira, President) studied the relationship between biodiversity and productivity using a theoretical model for communities composed of different sized phytoplankton, the base of aquatic food webs. The study demonstrated that the relationship between biodiversity and productivity depends on the frequency of disturbance, such as by drastic changes in environmental conditions. The work was carried out in collaboration with researchers from the Institute of Marine Sciences (CSIC) in Spain and the Leibniz Centre for Tropical Marine Ecology (ZMT) in Germany.

Biodiversity is known to be important for sustaining the productivity of ecosystems and for maintaining their resilience. However, different relationships have been observed between biodiversity and productivity, and the underlying mechanisms have remained uncertain. The team developed a continuous trait-distribution model for a phytoplankton community of gleaners (those species that do well when nutrients are scarce) competing with opportunists (species that do well when nutrients are plentiful) and subjected the model community to differing frequencies of disturbance, in order to examine diversity-productivity relationships. This study revealed that more diverse communities tend to be more productive in the short-term under frequent disturbance, because diversity enhances adaptive capacity, which is the ability to recover from sudden changes in environmental conditions. On the other hand, less diverse communities tend to be more productive over long periods with infrequent disturbance, because then the most productivie community is composed of (nearly) identical species having just the right traits (inherent characteristics) for the nearly constant environmental conditions. Taken together these results show that more diversity does not in all cases enhance productivity, but that the diversity-productivity relationship changes with the frequency of disturbance.

Marine life conservation is an important issue as “conservation and sustainable use of the oceans, seas and marine resources” has been set as one of 17 goals for a new sustainable development agenda in the UN Sustainable Development Summit of 2015. In terms of managing marine resources, these key findings suggest that the frequency and intensity of disturbance should be considered when allocating funds and other resources to sustain the biodiversity and productivity of the marine food chain and fisheries. Specifically, these new results suggest that it would be more important to limit the loss of biodiversity in areas subject to frequent disturbance, in order to maintain the adaptive capacity of ecosystems there, than in areas where disturbances are relatively rare, where the loss of biodiversity is less likely to reduce productivity.

This work was carried out as part of a project entitled "Development of a new ecosystem model to represent the adaptive capacity of plankton communities in the North Pacific" supported by CREST, Japan Science and Technology Agency (PI: S. Lan Smith).

The above results were published online in the journal *Scientific Reports (Nature Publishing Group)* on October 17 (JST).

Title: Phytoplankton size-diversity mediates an emergent trade-off in ecosystem functioning for rare versus frequent disturbances

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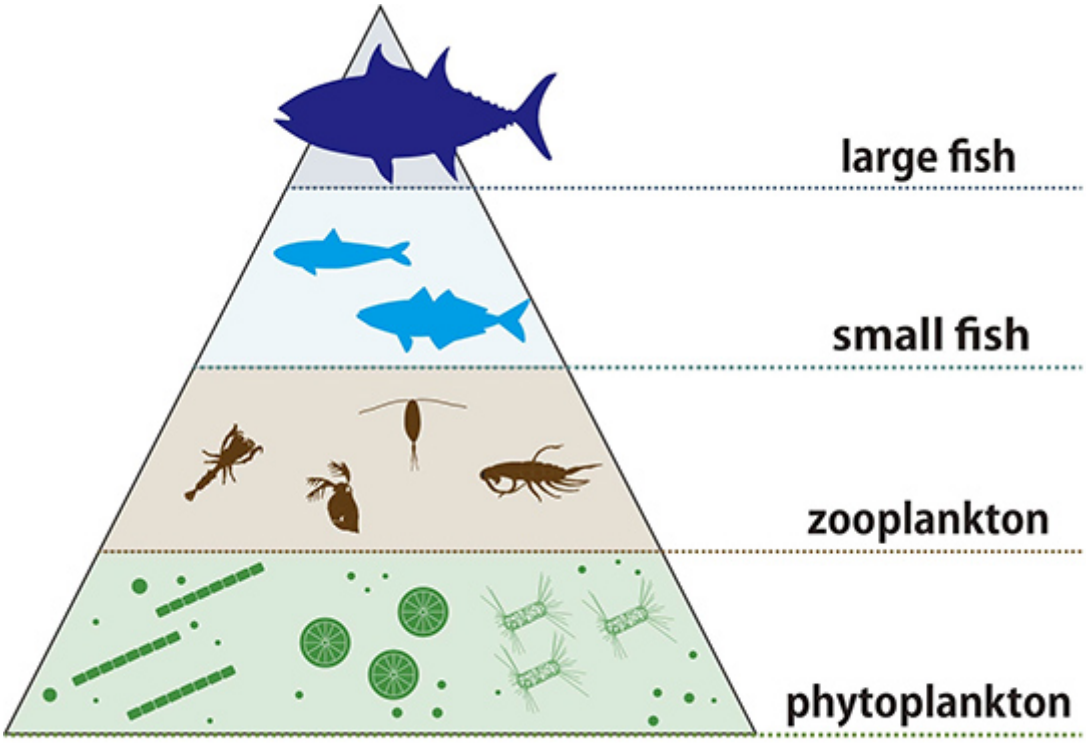

Figure 1. As the base of the marine food chain, phytoplankton (shown in green) are vital for sustaining the productivity of marine ecosystems.

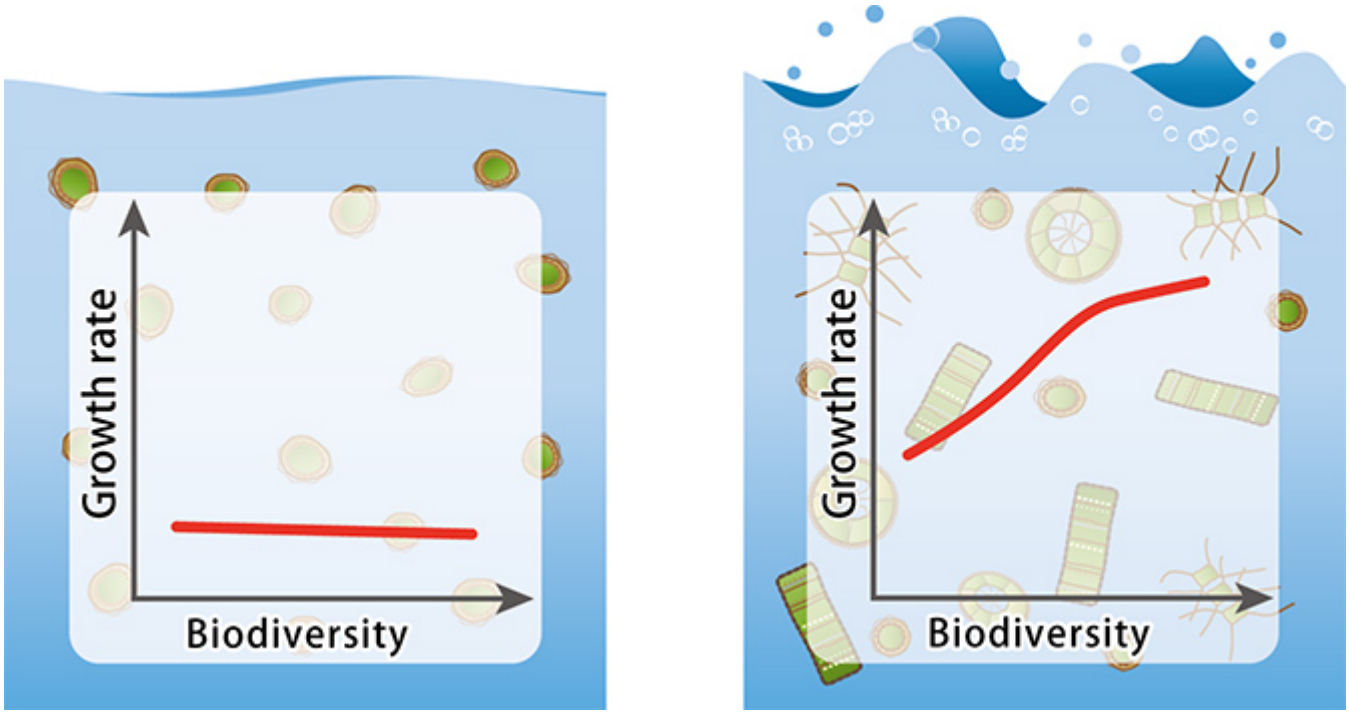

Figure 2. If the environment is under less frequent disturbances, a phytoplankton communities with less diversity tend to be slightly more productive (left). On the contrary, when disturbances are more frequent, more diverse communities tend to be more productive.

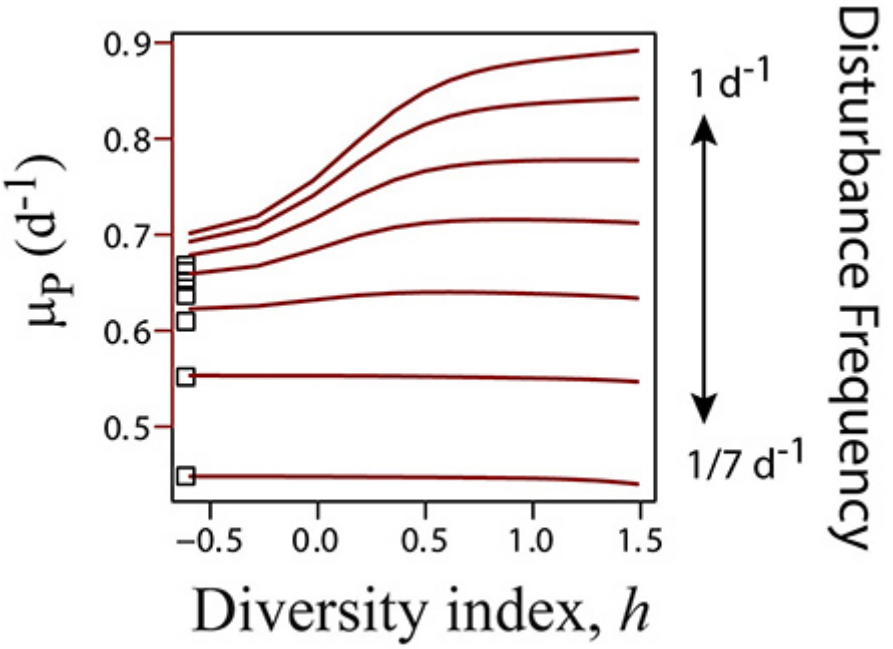

Figure 3. Results for the Productivity-Diversity relationship for the short-term (7d) average. Short-term Adaptive Capacity (AC) is quantified by the specific growth rate, μ_P, for the phytoplankton community (vertical axis, left side) averaged over the 7 day period after the beginning of disturbances. The horizontal axis (bottom) shows the size diversity index, h. The different lines show results for different frequencies of disturbance (shown by arrows on the right side), which were considered as drastic mixing events in the ocean, causing a sudden decrease in the phytoplankton biomass and a corresponding increase in nutrients. A high frequency of 1 d^{-1} means one disturbance per day, and a low frequency of 1/7 d^{-1} means one disturbance per week. Productivity tends to increase most strongly from low to intermediate diversity under frequent disturbance. However, under rare (low frequency) disturbance, more diverse communities are less productive.

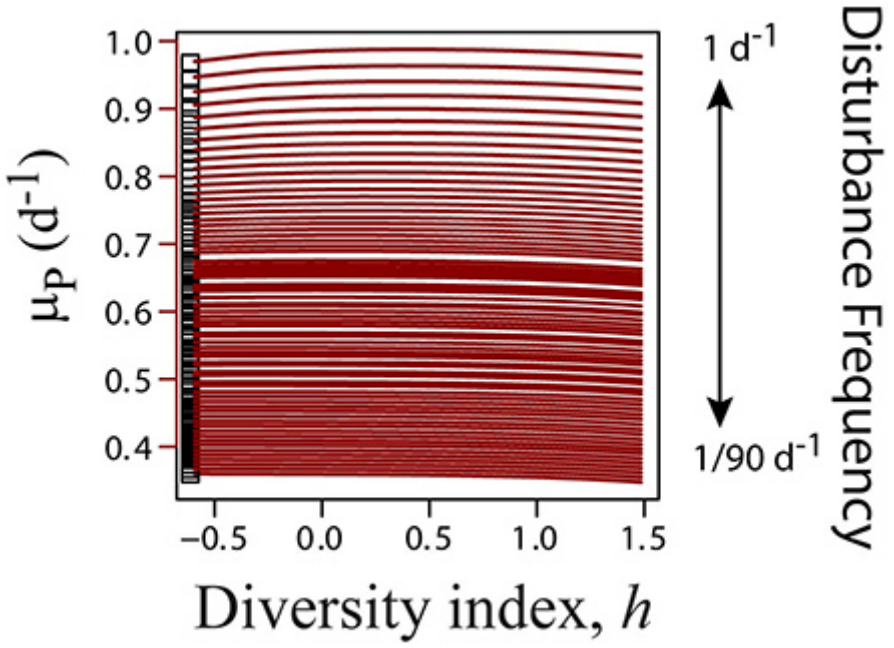

Figure 4. Results for the Productivity-Diversity relationship for the long-term (90d) average. Long-term Productivity (LP) is quantified by the specific growth rate, μ_p, for the phytoplankton community (vertical axis, left side) averaged over the 90 day period after the beginning of disturbances. The horizontal axis (bottom) shows the size diversity index, h. The different lines show results for different frequencies of disturbance (shown by arrows on the right side), which were considered as drastic mixing events in the ocean, causing a sudden decrease in the phytoplankton biomass and a corresponding increase in nutrients. A high frequency of 1 d^{-1} means one disturbance per day, and a low frequency of 1/90 d^{-1} means one disturbance per 3 month period. Under frequent disturbance, communities having intermediate levels of diversity are the most productive (fastest growth), but under infrequent disturbance, more diverse communities are slightly less productive.

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