

“Biological Production and Biological Environment” field

Achievement : Contribution to marine environmental conservation through research on ecology and biodiversity of deep-sea organisms

Dr. John Frederick Grassle

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Summary

It has been thought for many years that only a limited number of living organisms exist in the deep sea exceeding a depth of 200m, due to the fact that hardly any sunlight, needed for photosynthesis, reaches there. However, in 1977, a hydrothermal vent called a black smoker was discovered at the bottom of the Pacific Ocean, and the existence of a wide variety of organisms was recorded. Marine Biologist Dr. John Frederick Grassle organized an ecological survey mission using a manned research submersible, and clarified the existence of a chemosynthetic ecosystem in the deep ocean which utilizes not sunlight, but chemical substances supplied from the earth's interior.

Through his studies in the 1980's and the 1990's, Dr. Frederick Grassle proved that an abundant biodiversity exists in the deep sea comparable to that of the tropical rainforest. Furthermore, in 2000, a 10-year project which endeavors to shed light on the diversity, distribution and population of all marine life called “CoML: Census of Marine Life” was founded. The research findings thereof are greatly contributing to the preservation of the marine ecosystem which has rapidly been lost since the 20th Century.

Dream to become a marine biologist came true through the ecosystem study of coral reef benthos

Dr. Frederick Grassle, who is now acclaimed as a world-class marine biologist, was actually born in Ohio which does not have a coast. However, nearby was Lake Erie. During his junior high school days, Dr. Grassle developed a fondness for the underwater world, having read books written by Jacques Yves Cousteau, an inventor of the underwater breathing apparatus.

The opportunity for Dr. Grassle to become involved in oceanographic studies came when he was studying zoology at Yale University. His instructor encouraged him to participate in studies being carried out by the Woods Hole Oceanographic Institute in Cape Cod, Massachusetts. While continuing to gather marine species there, he cultivated a strong desire to become an oceanographer.

After earning a Ph.D. at Duke University in 1967, Dr. Grassle obtained the Fulbright-Hays scholarship and engaged in the study of the ecosystem of organisms living in the coral reefs of Australia. Coral reefs are known to have one of the most abundant biodiversities of all marine environments. In particular, Dr. Grassle focused on sandworms which live in the sediments on the ocean floor, and clarified the role which benthos play in the coral reef ecosystem that attracted little attention. Dr. Grassle even improved by himself the scientific instruments used in gathering life from sediments and cast a spotlight on a new dimension of the coral reef ecosystem.

Discovery of unique and abundant ecosystem in the deep sea floor which was previously believed to be a wasteland

Dr. Grassle, given recognition on research findings on coral reefs, was recruited as a member of the Woods Hole Oceanographic Institute in 1969. In the 1970's, it was the exploration of the deep ocean this institute embarked on. At the time, the plate tectonics theory was in its development period, and it was thought that many

undersea volcanoes and hydrothermal vents existed in the area on the ocean floor where a new crust was formed (diverging plate boundaries), which many sought to discover. Thereafter in 1977, by means of the survey conducted by geologists on the “DSV Alvin,” a manned research submersible, made a stunning discovery of a hydrothermal vent called a black smoker in the deep ocean floor of approximately 2500m, near the Galapagos Islands. It was confirmed that a diversity of living creatures existed there.

Dr. Grassle, who came to know of this report, conducted his own survey on the DSV Alvin in 1979. The survey team on this expedition succeeded in obtaining some amazing footage. The black smoker blasted out hot water at over 400°C, which contained such toxic compounds as hydrogen sulfide. Based on the common knowledge of the times, such was an environment unfit for life, yet near the hot water vent right before his eyes, tubeworms which poked their red heads out of their tube-shaped shells, as well as bivalves, were growing in clusters.

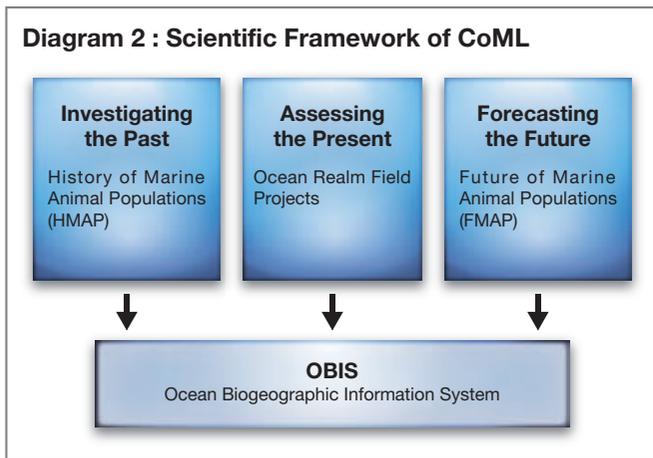
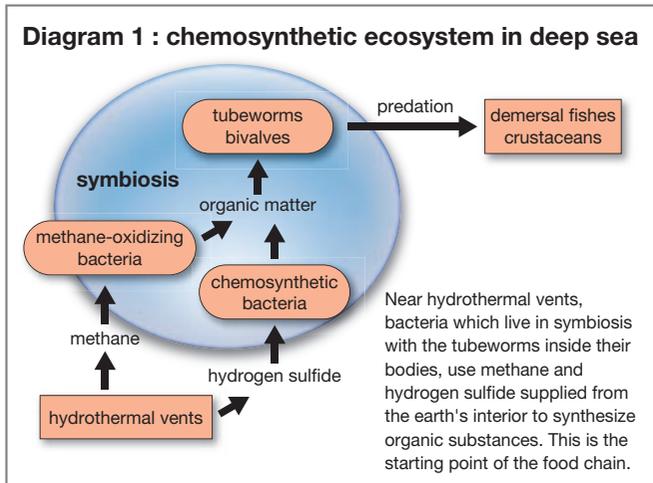
Up to that point in time, life was thought to be dependent mainly on sunlight as its main energy source, and the greater part of the ecosystem on earth was supported by organic substances synthesized by photosynthetic organisms. In other words, the deep sea where light does not reach was thought to be a desert-like place where only a limited number of organisms which are supported by organic substances precipitated from the shallow waters could exist. However, it was verified that in reality, the deep sea has an abundant ecosystem beyond our expectations. At that time, Dr. Grassle confirmed, “These organic matters must be obtaining their energy source not from sunlight, but from methane, hydrogen sulfide and other substances which are supplied from the earth's interior.”

Dr. Grassle's idea was backed up by many studies thereafter, and the ecosystem using chemical substances came to be called the “chemosynthetic” ecosystem, a word used as a counterpart for “photosynthesis.” Such microorganisms as sulfur-oxidizing bacteria support the chemosynthetic ecosystem. The microorganisms oxidize the chemical substances found in hot water such as hydrogen sulfide and hydrogen, and use the energy obtained to synthesize organic substances from carbon dioxide. Such large organisms as tubeworms exist by taking in such microorganisms into their bodies and “coexisting” with them (Diagram 1).

The discovery of the chemosynthetic ecosystem exerted a great influence in a wide range of biological fields. The research on the origin of life is one of them. For example, it came to be believed by many scientists that if there are volcanic activities, there is a possibility of life even in planets and satellites in the space where hardly any sunlight reaches and most of the water exists in the form of ice.

The founding of the CoML Project sheds light on marine biodiversity

During the 1980's and 1990's, Dr. Grassle enthusiastically carried out studies on the biodiversity of marine life in the deep sea. Dr. Grassle took notice of the fact that there are areas on the ocean floor in the eastern part of United States at a depth of 1500 m to 2500 m where there is an abundance of biodiversity. He divided the area into small sections and surveyed the types and numbers of marine life found. As a result, he clarified that the patch-mosaic dynamics can be applied as a mechanism for supporting biodiversity even in the deep sea. In other words, even in a seemingly uniform deep sea environment, there is a complex adaptive system in which a diverse environment exists on a minute scale called patches. Ever-changing patches spread like mosaics, resulting in a wide variety of life. From a quantitative study of such deep sea ecosystem, Dr. Grassle could conclude that “an abundant biodiversity exists in the deep sea comparable to that of the tropical rainforest.”



With this study as a motivational force, Dr. Grassle aimed to clarify on the diversity of all marine creatures and embarked on developing a worldwide network. In 1989, the base of operation was moved to the Institute of Marine and Coastal Sciences at Rutgers University in New Jersey where various research projects have been carried out, including the most well-known CoML, of which Dr. Grassle is a co-founder. CoML is a global marine life research network with researchers now from over 80 countries. In a 10-year project from 2000 to 2010, diversity, distribution and population of marine life have been surveyed and analyzed. In addition, Dr. Grassle has had a strong interest in environmental preservation and has held a conviction that reliable scientific data is indispensable for environmental preservation. To that end, he has devoted his energy to make available the research results of CoML in the form of an Ocean Biogeographic Information System (OBIS) database (Diagram 2). The summary of the CoML findings released in 2010 revealed that 90% of the thousands of new species and marine life consist of microorganisms.

At present, marine diversity is rapidly decreasing, and a major contributing factor is the depletion of fishing resources. By means of the CoML survey, not only has the marine region needing the most preservation been highlighted, but it has also contributed in the setting of standards with respect to evaluating future changes from climate change and overexploitation due to fishing. In addition, OBIS is presently being managed by UNESCO/IOC, and is being used worldwide in drafting preservation policies regarding marine life.

How should we continue to preserve the marine biodiversity clarified by Dr. Grassle through his deep sea research? That is one of our major challenges for the 21st Century.