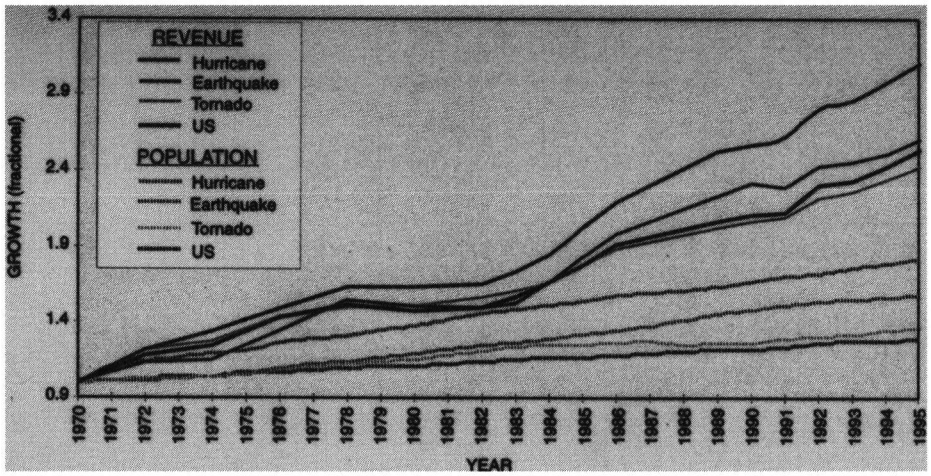

Fig. 4. Fractional growth (relative to 1970) of population and revenue in disaster-prone areas of the United States [U.S. Census Bureau, 1997b]. Original color image appears at the back of this volume.

processes that build our landscape and shape our environment.

Acknowledgments

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Steps Proposed to Resolve Potential Research Conflicts at Deep-Sea Hydrothermal Vents

PAGES 533, 538

Biological researchers studying deep-sea hydrothermal vents occasionally find themselves at odds with their colleagues. The main issue is the incompatibility of two types of investigations—some are aimed at understanding how vent systems function by monitoring them in an undisturbed state and others study processes by manipulating the system or collecting parts of it, or both. The research community could resolve this conflict, we believe, by embracing the concept of deep-sea hydrothermal vent reserves and by adopting a fair and equitable process for establishing reserves and disseminating information about them. At the same time those who need to manipulate the system or collect specimens could work at nearby sites and share data and samples.

The first two decades of vent research witnessed a remarkable period of discovery—new sites, novel organisms, and unusual adaptations. Dozens of new vent fields and hundreds of new species later, exploration of unknown areas of the global ridge system is no longer the primary driver for discovery in hydrothermal vent biology. As the third decade begins, a diminished exploration effort is tied to new developments in vent research that emphasize temporal processes, therefore requiring time series observations at fixed locations. Shifting of investigative effort to the time domain is resulting in the concentration of sampling, observation, and instrumentation at a small number of well known hydrothermal sites. The potential returns from coordinated, multidisciplinary time series studies are tremendous, and organizations in several countries are encouraging biologists and Earth scientists to work together at single locations to investigate linkages between the processes they study.

Imagine, however, this scenario. You are the chief scientist on a research expedition to study deep-sea hydrothermal vents. You have a ship full of investigators who represent many nations and who all have specific needs for imaging, measuring, and collecting a variety of entities, including rocks, seawater, and organisms. The scientists are bringing cameras and other instruments that will be towed at the end of a long cable, current meters that will be moored on stations, and containers full of gadgets to attach to the submersible. You are responsible for ensuring that none of these activities has a negative impact on the others. On top of all this, you have a set of instructions from another set of investigators forbidding you to manipulate, or perhaps even to visit, some of the most intriguing vent fields in the vicinity of your study site. How can you possibly accommodate everyone's requests while optimizing the scientific productivity from your cruise?

This dilemma is now faced by virtually every research team that visits hydrothermal vent systems along the Mid-Atlantic Ridge, the East Pacific Rise, and the northeastern Pacific. The problem is likely to spread to other vent sites as they become more frequently visited. The observers wish to set aside sometimes quite large areas for reserves, to be monitored and measured but not disturbed. The experimentalists want to set aside sites for controlled manipulations and subsequent observation, and the collectors want access to sites for removal of substantial numbers of specimens.

Ideally, the vent system will be best understood through a combination of these various approaches, but that goal requires altruism and cooperation among all scientists involved in field investigations of vent systems. The culture of science and the reality of international research prevent the imposition of top-down regulation by any one individual or organization. Instead, the cooperation must be obtained through consensus.

The concept of ecological reserves has a long history of acceptance for ecological studies and environmental preservation in both terrestrial and marine environments. For deep-sea vents, the idea of designating

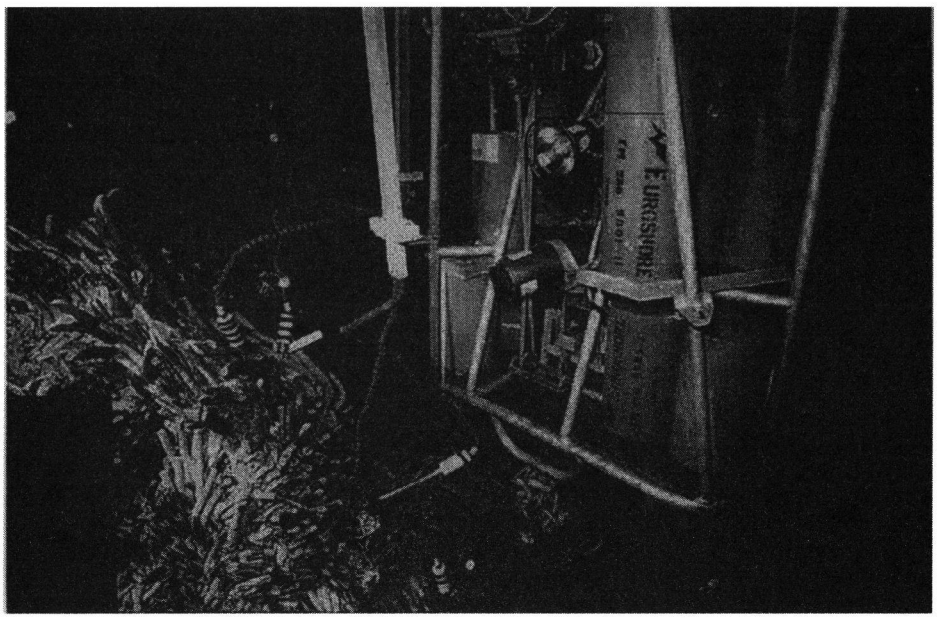

Fig. 1. Example of noninterventive observatory studies at 13°N East Pacific Rise. The station Autonome de Mesures Océanographique (SAMO) was placed in front of this tube worm colony by the submersible Nautile to record tube worm behavior in relation to environmental conditions. During the 30-day deployment SAMO's four temperature probes continuously recorded temperature at the base and tip of the tube worms, a video camera acoustically transmitted digitized images every three minutes to the surface ship, and bottom currents and turbidity were recorded by instruments (not visible) mounted on the upper part of the instrument platform. Photo by IFREMER. Original color image appears at the back of this volume.

reserves was informally introduced during discussions at international meetings and symposia in the early 1990s. A more formal recommendation to explore the concept of seafloor reserves in terms of respect for ongoing experiments and instrument deployment as well as biodiversity issues was made by a group of biologists in 1995 [*Biological Studies Ad Hoc Committee*, 1996].

The case for establishing research reserves at hydrothermal vents is compelling. Long-term observations of vents and their associated communities have provided a wealth of information and new understanding. There is no question that disturbance by researchers can have a substantial impact on vent systems, particularly on faunal communities. Anthropogenic changes in the distribution and occurrence of vent fluid flows and of associated vent communities have been well documented at vents along the East Pacific Rise, on the Juan de Fuca Ridge, and at the TAG field on the Mid-Atlantic Ridge. A complete understanding of vent systems, however, requires a diverse and balanced approach of observation and experimentation.

For reserves to be established and recognized, however, requires a means of fast and efficient international communication. Towards this end, an organization known as InterRidge has set up a Web-based information site on deep-sea reserves at hydrothermal vents (http://www.lgs.jussieu.fr/~intridge/reserve.htm). InterRidge, an international and interdisciplinary initiative concerned with all aspects of mid-ocean ridges, is designed to encourage scientific and logistical coordination with particular focus on problems that cannot be addressed as efficiently by nations acting alone or in limited partnerships. Its activities range from dissemination of information on existing, single-institution experiments to initiation of fully multinational projects.

The InterRidge Web site will create a forum where researchers can propose vent reserves, and where others in the oceanographic community can respond to them. If, for instance, a large reserve is proposed at a site where experimentalists have a history of working, then that reserve is not likely to be acknowledged by the community. If, on the other hand, a small reserve is proposed in a region where it will not prevent ongoing manipulative research, then it will likely be honored. The research reserve system will be regulated entirely by consensus, but InterRidge will play a role in disseminating the information and summarizing controversies if they arise. The Web site will be of general use in several ways: seagoing researchers will have a single source of information on regions where ongoing research is being conducted, and the community will have a forum for holding proposed reserves up for scrutiny.

In addition to the reserve concept, InterRidge has been working on the development of a mechanism for the open exchange of preserved and frozen hydrothermal biological samples. This would provide material for studies of the biogeography and evolution of vent species and help avoid duplicate sampling, which is costly in human, monetary, and ecological terms. For the past 2 years, InterRidge has been working on a draft of a formal sample exchange agreement. An open meeting during a 1997 vent symposium made it clear, however, that a system for gathering, organizing, and disseminating information on biological samples would facilitate international sample exchange much more effectively than a formal written agreement. In response, InterRidge has devised a form to send to sea with biologists and has developed a Web page to display the contributed listings of biological specimens from future cruises (http://www.lgs.jussieu. fr/~intridge/ samp-db. htm). This is the first step toward the development of a comprehensive listing of biological samples from present and past cruises.

Scientists who wish to obtain specimens from listed collections can then contact the responsible individual and make a request. The terms of the exchange will be up to the individuals involved, and curators of specimens may well refuse if they need the specimens for ongoing investigations. Suggestions for the terms of an exchange are provided by the Biological Studies Ad Hoc Committee [1966] and on the InterRidge Web site.

Recognition of the need for protected reserves carries with it an obligation to provide samplers with fresh specimens. Some pressure on the more popular vent sites can be relieved by a modest exploration effort to identify new vents to provide fresh material for shipboard physiological and biochemical studies. Just as we must educate funding agencies and the peer-review community as to the importance of the reserve concept, we must also convince them of the need to spend valuable submersible bottom time looking for new vents in the vicinity of the protected areas. Adding one or two dedicated exploratory dives to future cruises could go a long way toward easing the task of the chief scientist, who must juggle the interests of the observers and the samplers.

The concept of deep-sea reserves has much broader implications than those related to the competing goals of a handful of scientists. The preservation of biodiversity in these vulnerable habitats is also a currently debated issue. Especially with the recent disclosure of plans to extract minerals and metal from vent habitats in the South Pacific, environmentalists and ecologists are calling

for establishment of specific vent areas as reserves from mining or any other harmful human activities. Scientists have an obligation to provide sound information on the distribution, structure, and function of vent communities to the national and international governing agencies that will be deciding their fate. We also have the opportunity to provide a model for coordination and cooperation among diverse interests in the resources at vent systems.

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FALL MEETING PREVIEW

NSF-Sponsored Sessions Explore Opportunities in Solid Earth Sciences

PAGES 533–534

To help the National Science Foundation (NSF) prepare a "template" to prioritize and guide its programs and funding in the Earth sciences over the next decade, the foundation is sponsoring a special oral and poster session at the AGU Fall Meeting in December. The sessions, along with one held at the Geological Society of America (GSA) conference in October, are kicking off an effort that will culminate in a National Research Council (NRC) report issued toward the end of the year 2000, according to Ian MacGregor, director of the NSF Division of Earth Sciences and poster session coconvenor.

The AGU sessions, "Research Opportunities in the Solid-Earth Sciences: A 10-Year Vision," include discussions of research opportunities in atmosphere/solid Earth interfaces, planetology, geomagnetism, paleomagnetism, and other disciplines.

The talks and posters will provide NSF with an opportunity to gain input from a cross-section of the community about Earth science priorities, MacGregor said. He is particularly concerned with determining what should be the proper balance between support for facilities, research, and education; whether there are some particularly timely issues that should be tackled soon, perhaps due to intellectual developments and technological advances that have positioned certain research areas at seeming thresholds of discovery; and what compelling societal needs should receive priority attention from the Earth science community.

NSF's previous report on Earth sciences priorities–released in the mid-1980s–laid out a steady road map, and 80-90% of its goals were met, he said. "I'm hoping that this current group can correspondingly give us the same kind of visionary charge," MacGregor added.

The new report also may discuss the balance between basic and applied research, and the increasing need for multidisciplinary scientific approaches, said Anthony deSouza, study director for the NRC committee and another poster session coconvenor.

In addition to the sessions at the AGU and GSA meetings, the 14-member NRC committee also plans to hold six formal meetings, and possibly sponsor several workshops, beginning in 1999, deSouza said. The committee, he said, will be chaired by Massachusetts Institute of Technology Seismology Professor Thomas Jordan, a coconvenor at the AGU oral session, and will include scientists in four broad categories: those involved with deep Earth processes, crustal-lithospheric processes, surface interactions, and Earth resources.

"We made a strong effort to put together a committee whose members are not only distinguished in their specialties, but also have a broad appreciation of current challenges and opportunities in Earth science beyond their specialties, as well as understanding how the Earth sciences integrate with all of science and technology," deSouza said.

AGU session presenters include John Orcutt, professor of geophysics at the Institute of Geophysics and Planetary Physics at the Scripps Institution of Oceanography in La Jolla, Calif. He said the NSF plan should encourage research and education that is not confined to strict geographic and disciplinary barriers, and that "is planned around scientific challenges and problems rather than around bureaucratic decisions."

NSF divisions between Earth, atmospheric, and ocean sciences "often enforce the artificial segregation of disciplines in many academic institutions and government laboratories," Orcutt wrote in the abstract to his talk on "Global Earth Science." "While the future of the Earth sciences should be very difficult to predict a decade into the future, this predictability is greatly enhanced by these divisions. An exciting future for Earth sciences can be anticipated only if bureaucratic and cultural barriers to the growth of the field, as a whole, can be removed."

Other examples of what Orcutt means by artificial divisions of geographic study include a network of broadband seismic stations across the United States that does not venture beyond the shorelines and a few islands—although continents extend offshore. He also wondered about the rationale behind having separate departments within NSF to deal with Earth sciences and polar programs. "Are the Arctic and Antarctic the points where science changes across those borders? But that's how they fund science today," Orcutt said. He added that the study of the polar regions is "completely decoupled" from other regions, and that this distinction makes no sense if one is trying to understand the Earth system.

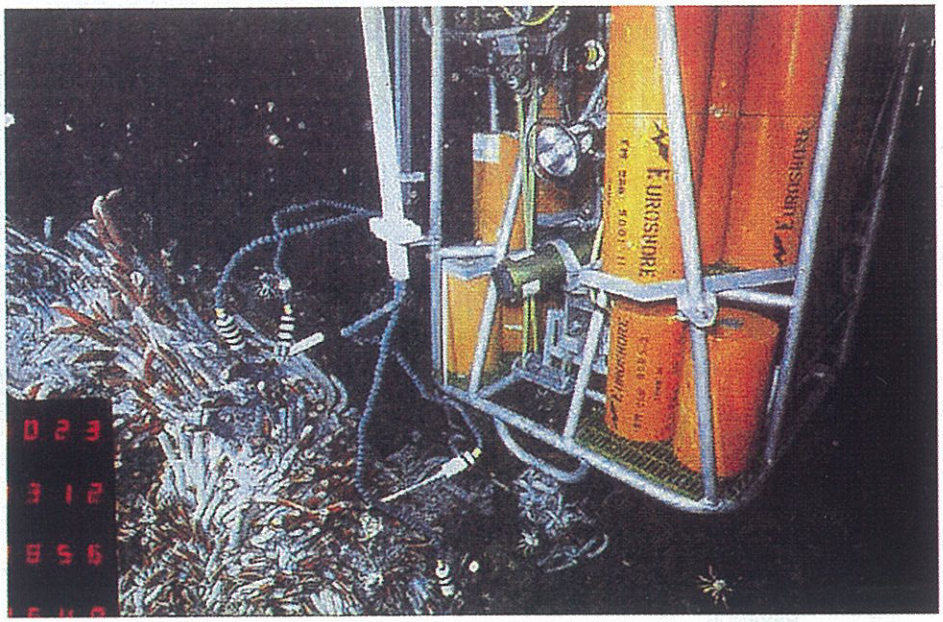
Orcutt also made a case for increased multidisciplinary research. To study the carbon cycle, for example, it is important to understand biomass, he said.

Orcutt said that the margins between two areas often is where much of the interesting research occurs. Both NSF and the science community, he said, can choose to foster change, or not foster it and settle instead for incremental progress in disciplines.

"I'd prefer a tumultuous, change-ridden kind of science than the kind of thing you could predict," he said, adding that it would be more fun, better for young people entering scientific fields, and possibly make science more flexible to meet research opportunities and societal needs.

Research into atmosphere and solid Earth interfaces is another field with challenging opportunities, said Marvin Geller, dean and professor of atmospheric sciences at the Marine Sciences Research Center at the State University of New York at Stony Brook. At the AGU session, Geller will discuss atmospheric effects of volcanoes, coupling of atmospheric angular momentum to that of the Earth, soil hydrology impacts on climate modeling, and other areas. Geller added that multidisciplinary research and study is emphasized at Stony Brook. The study of soil hydrology, for instance, requires some understanding of biological components that might affect the retention or evaporation of water, and the perturbation of sediments, he said.

Research opportunities in geomagnetism and paleomagnetism also will abound over the next decade, according to Robert Coe, professor of Earth sciences at the University



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