Book Review: The Universe Below by William J. Broad

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Given the dimensions of the earth in comparison with the size of life forms that are spread over its surface, the collective biosphere is no more than a thin film on the earth's surface, like an oil slick on a puddle, colorful and fascinating but essentially two dimensional and fragmented. The biosphere is thickest near the seashore with lowland forests and swamplands landward and fishing banks and coral reefs seaward. Until recently it was generally thought that most life in the deep sea occurred in the photic zone, which is the upper most 100 meters or so where light still penetrates. Below in the abyssal deep were thought dwelled only a few strange bottom creatures who survived in total darkness and crushing pressure on the debris raining down from the more abundant life above.

William Broad reports on a different, recently evolving spatial model of life's domains, in which the biosphere extends throughout the volume of the oceans down to the bottom of the deepest trenches. This three dimensional space greatly exceeds the volume occupied by all living things on land and at the ocean surface. And contrary to previous beliefs, this domain is proving richer and more varied of life forms than even Jules Verne imagined. Small, systematic samples are revealing numerous new species with great variation from place to place. The number of species of life in the deep is now thought likely to exceed the number of all land creatures and plant species at the earth's surface, although this fact remains uncertain because of our sparse knowledge of deep sea life. Some of the newly discovered deep sea species exist in food chains that are independent of the sun's energy. They live entirely on heat and minerals brought up from the depth of the earth through undersea volcanic fissures. The huge, dark, and largely unknown three-dimensional space of the oceans is the *universe below*.

In his book, Mr. Broad reports on the human efforts to probe this world beneath. The exploration began tentatively in the Nineteenth Century and has only been vigorously pursued in the second half of the Twentieth Century. The pace of the exploration quickened in the last decade of the century with access to new and powerful technologies. Mr. Broad divides his chronicle into seven chapters each devoted to one facet of the efforts to enter and explore the deep oceans. He begins with a history of early attempts to penetrate the depths. The huge weight of sea water is the problem. Ten cubic feet of sea water equals roughly one cubic foot of lead. The Titanic rests 2 1/2 miles deep, which is about the average depth of the oceans, and where the water pressure is equal to the weight of a tower of lead the height of the Empire State Building. Life forms of the deep, being made primarily of water that is nearly incompressible, are indifferent to the pressure. Anything hollow or containing a cavity, including humans and many of our devices, are disastrously affected by the pressure, hence, the difficulty in exploring the depths.

In one of the continuing ironies of our age, the military pioneered the technology that opened the oceans to exploration. They made the deep sea a battlefield in the Cold War. The military were not interested in

exploration. Their interest was in being able to operate in deep water to support submarine warfare and undersea espionage. The United States developed a technological advantage over the Soviet Union by investing huge resources toward these purposes. Mr. Broad describes several defining events that shaped this effort. For example, in April, 1963, the USS Thresher, the most advanced attack submarine of its day, inexplicably sank, its 129 men lost in water more than a mile and a half deep. The Navy had no way to reach the ship to salvage sensitive equipment or to investigate the mystery of why she was lost. The tragedy led to much greater expenditure on the development of deep submersible craft ostensibly to make possible deep sea rescue operations but also to expand the possibilities for undersea espionage through use of search and salvage capacities to be used to obtain intelligence from sunken Soviet ships, especially nuclear equipment and devices from submarines lost at sea.

Mr. Broad is a Pulitzer prize winning science writer for the New York Times. His investigative powers are evident in this book as he details the political and policy debate that took place in Washington to direct resources into the Navy's deep submersible operations. Most of the effort was to support espionage which was in line with the tendency of the United States to depend upon technological means for conducting espionage instead of relying on spies and secret agents. After the end of the Cold War much of this military technology was declassified and is now being used in civilian efforts at exploration. Russian equipment is also available for hire and lease as the Soviet Union had also developed deep submersible capabilities during the Cold War.

The chapter on military efforts sets the stage for the remaining chapters by appraising the reader of the difficulties of undersea operations and how the technology addresses them. The rest of the chapters detail the exploration. Chapter three describes a dive in the Pacific Ocean off the Oregon coast in which the author was a passenger of the Alvin, a Navy deep submersible being used by NOAA (National Oceanographic and Atmospheric Administration) to explore undersea volcanic chimneys or smokers around which strange life forms cluster. Chapter four is a report on enterprises that seek to gain fortunes by finding and scavenging lost treasures from shipwrecks buried in deep waters. Deep sea salvaging remains a very expensive activity. Investors want to recover costs by claiming gold and other precious materials or by exploiting public interest in shipwrecks such as with the Titanic. The story reveals that what the technology has now brought within grasp becomes enveloped in controversy over ownership, and moral and ethical issues.

A deep canyon, greater in size than the Grand Canyon, lies beneath Monterey Bay off the central California coast. Because the deep water is very near shore, land-based excursions can frequently be made with much less expense than dives of deep submersibles operating from support ships far out at sea. Chapter Five describes the activities of a research group, whose primary funding comes from David Packard, the billionaire co-founder of the Hewlett-Packard Company. This group, associated with the famous Monterey Bay Aquarium, is using unmanned vehicles to monitor undersea life at all levels to below a mile deep. They are finding an unexpectedly broad range of life forms, which for the first time can be observed in their natural habitat, including many creatures that live at mid-water depths. These life forms have been missed by marine biologist in their rush to the bottom. The Monterey Bay Canyon site is becoming a standard model for deep sea ecology because of the level of exploration but this may be misleading. Other parts of the oceans, though sparsely sampled, reveal different collections of new

species that leaves open the questions of total number of species.

Scientist and fortune hunters are not the only groups interested in deep sea exploration. Commercial interests, encouraged by governments throughout the world, are seeking to exploit deep sea resources in large scale commercial ventures. Chapter Six describes these ventures that include deep sea mining and deep sea fishing. Miners are after petroleum and gas under deep sea beds, manganese nodules on the sea floor, and even the minerals dissolved in sea water. Vast amounts of metals and other minerals exist in seawater but no practical way of extracting them exists. The manganese nodules, which contain traces of other metals as well, are thought to have developed through a bio-concentration process which makes the metal aggregations more accessible than in seawater. The modules lie on the seabed in some places like a vast field of cobblestones. Proposed means for mining them call for robotic machinery to sweep over large territories gathering the nodules and discarding debris. The prospects immediately raised concerns by environmentalist who foresaw likely untold damage to a largely unknown ecology.

The Reagan Administration seized upon the possibility of deep sea mining as a way to develop reliable sources of strategic materials independent of foreign nations. This American stance was in opposition to one of the provisions of the Law of the Sea which proposed that all minerals on or below the ocean's floor belong to all of the people of the world that should be developed by a United Nations enterprise. On the other hand, the United States readily accepted the Exclusive Economic Zone provision that granted to coastal nations ocean resource development rights out to two hundred miles of adjacent oceans. The long American coast lines plus Pacific island possessions and protectorates created a huge American dominion, by far the largest of any nation. Industrial states have staked out large parts of the Pacific Ocean in anticipation of deep sea mining operations. Actual mining has yet to materialize because deep sea operations have to date proved too expensive to undertake.

Deep sea fishing, that is, fishing at great depths is another matter. Several coastal powers have claimed rights to fish resources found at great depth that are within their two hundred mile exclusive zone. For example, New Zealand commercial fishermen found dense schools of orange roughy about one half to one mile deep over a large sea plateau within their exclusive zone. This led to a rapid commercialization in which factory ships equipped with freezers were employed and the product exported to American and European markets. Huge profits were obtained as fish catches from competitors working established fishing banks were in decline. Unfortunately scientists discovered that the orange roughy and other deep fishes could live for more than one hundred years, some of the oldest living creatures on earth. Their slow growth and reproductive cycle makes them highly vulnerable to over exploitation.

One interesting new resource is exclusively a product of the abyssal environment. The huge pressure at great depths keeps water in liquid form even though water emanating from the volcanic smokers is very hot, well above the boiling point of water at one atmosphere. Microbes have been found living in this hot environment in which no terrestrial organism could survive. There is a use for these microbes. Microbiologists use enzymes obtained from bacteria to multiply minute bits of DNA (deoxyribonucleic acid) until sufficient quantities become available for analysis and manipulation. Tiny bits of DNA found at crime scenes can be used to identify individuals involved in an incident. Many other amazing applications of genetic material are being discovered and all use microbes as the factories for

multiplying the DNA. The best microbes for this purpose are ones that can withstand high temperatures, a fact first found by work with microbes that live in Yellowstone Park hot springs. The heat-loving microbes from the environment of the deep sea hot smokers yield enzymes that do not break down at high temperatures. New levels of purity and efficiency in producing genetic materials are possible because the chemical reactions involved can be carried out at temperatures that destroy any other bacterial contaminants.

The final chapter contains warning of detrimental human impact on the universe below. In the early years of the atomic age radioactive wastes were routinely dumped in deep waters just off-shore from populated coastlines. Most nations ended this practice but the radioactive level in several hot spots around the world remain very high and are not well contained. Other biologically active pollutants are also reaching the abyssal deep in waste streams from coastal industrial and urban sources. Human induced environmental change through contamination and over exploitation has resulted in irreparable damage to other ecosystems. We would be well advised to take care of next wilderness that we are beginning to enter.

Mr. Broad's book is and informative and interesting. He provides detailed notes and references throughout the book to document his information sources. He also provides a useful glossary, a chronology of important events in deep ocean exploration, and a bibliography. Beyond presenting a well written and structured book, he engages the reader with a sense of wonder that come from exploration of a domain on earth still unknown in modern times.

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